Forest Health Conditions

in

Wisconsin

Annual Report

2000

Compiled and Edited by

Forest Health Protection Staff

Wisconsin Dept of Natural Resources

PO Box 7921

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"What we do"

Forest Protection

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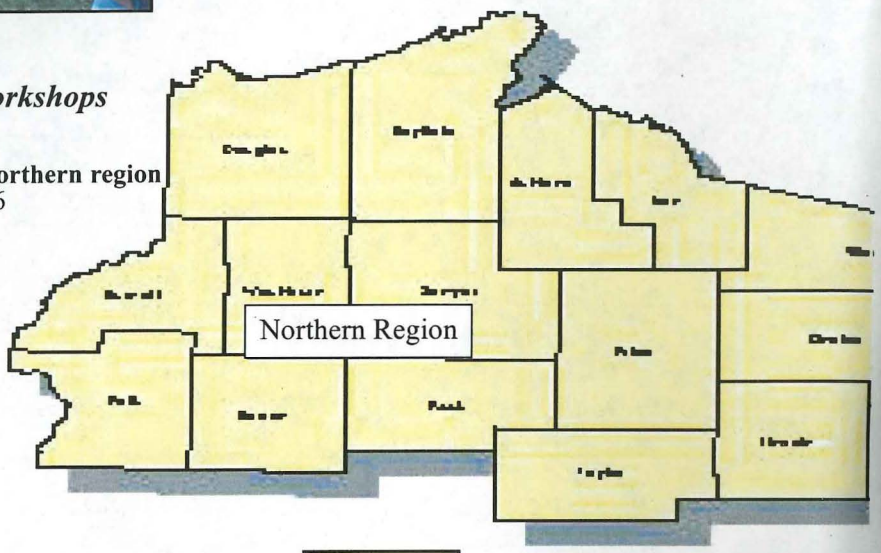

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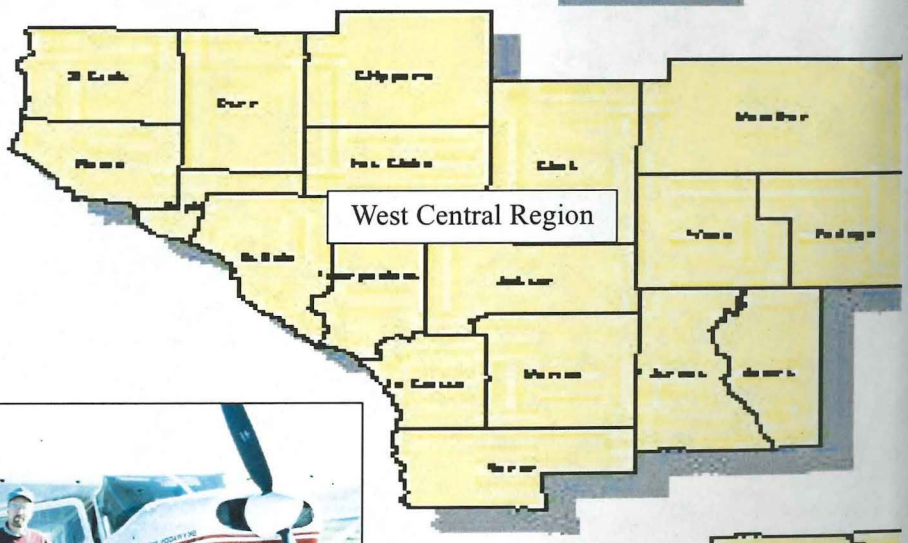

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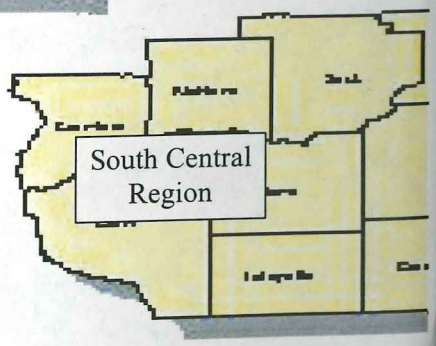

Table of Contents

Staff 2

Alerts 4

Peach bark beetle (Phloeotribus liminaris) 4

Orthotomicus caelatus (Eichhoff) 4

Comandra Stem Rust (Cronartium comandra) 4

The Resource 6

Major Issues 8

Forest Tent Caterpillar 8

Oak Wilt 9

Fall Cankerworm 10

Jack pine budworm 11

White pine blister rust 12

Resistance Study in Northwest Wisconsin Seed Orchard 12

Testing the Validity of Risk Zones for White Pine Blister Rust in Wisconsin 12

Wind and Hail Storm Damage 13

Minor Issues 18

Ash Yellows 18

Bruce Spanworm 18

Larch Casebearer 18

Butternut Canker 18

Exotic Pests 19

Multicolored Asian Lady Beetle 19

European Buckthorn (Rhamnus cathartica) 19

Other Pests Reported in 2000 20

Appendices 26

Forest Health Monitoring 26

Results, Comments, and Locations of Annosus Root Rot (Heterobasidion annosum) Aerial and Ground Survey's 2000 30

Root Isolation Trial for Detection of Annosus Root Rot 33

Lake Wissota State Park Red Pine Pocket Decline Study 35

Insects and Pathogens Affecting Forest Health of Red Pine 36

Last Stand for the American Chestnut: West Salem, Wisconsin 39

Jack Pine Budworm Survey Procedures and Results: 2000 41

Techniques for Surface Creation using ArcView Mapping Software 43

Assisted and Natural Spread of Parasitoids and Diseases in Newly Established Populations of Gypsy Moth: The Wisconsin Experience. 49

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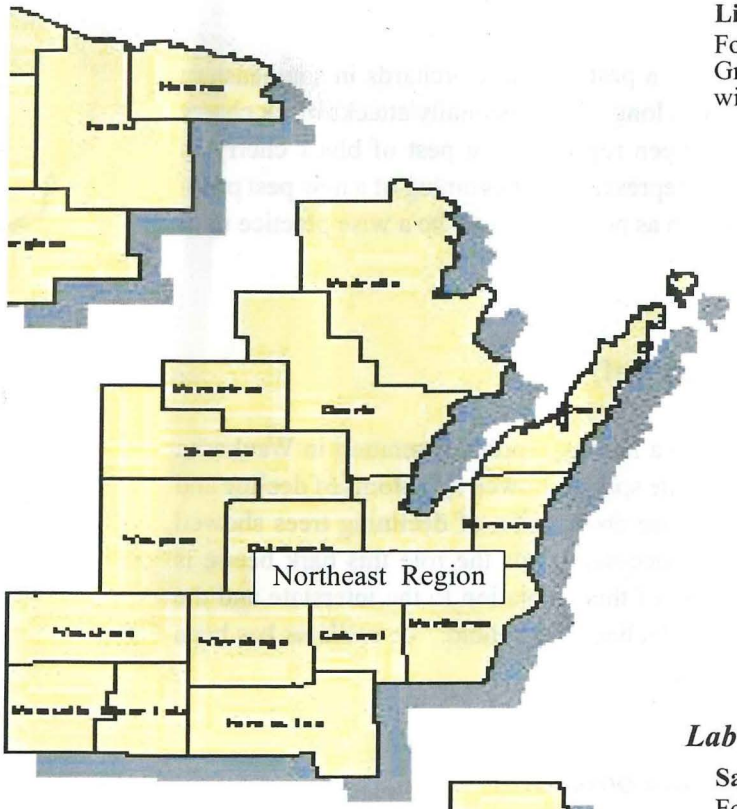

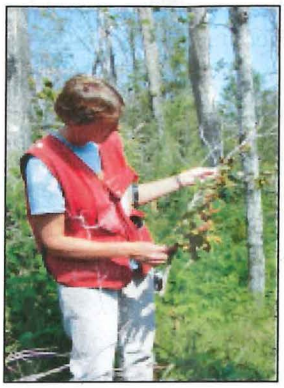

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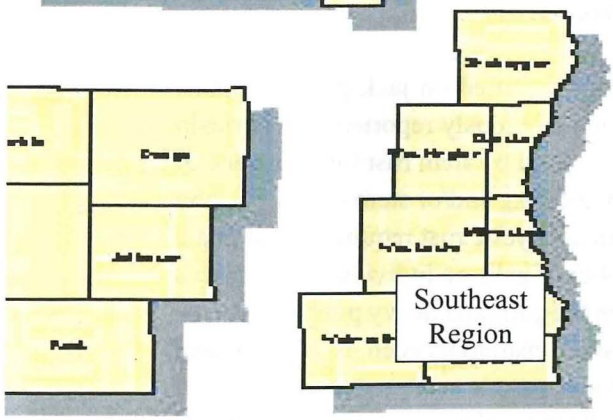

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Alerts

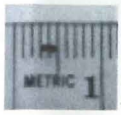
Peach bark beetle *(Phloeotribus liminaris)*

Many pitch globules from multiple beetles attacking black cherry.

This tiny bark beetle attacked mature black cherry in late summer after emerging from logging slash resulting from a September 1999 harvest. Many large-diameter tops produced ideal host material for the beetle population to build up. This years late summer attacks on the residual cherry produced many conspicuous globules of gummy pitch. Dissection revealed large numbers of adult beetles that had bored into the live bark but did not reach the cambium. It is too early to know if they will successfully attack next spring.

A second infestation was found in a nearby woodlot where a single black cherry was attacked where a windstorm had broken the tops out of several large-diameter black cherry trees.

This species is native to Wisconsin; it is a pest of peach orchards in southeastern U.S. The adult is tiny — 1½ to 2 millimeters long . It occasionally attacks black cherry that is under stress. It has not previously been reported as a pest of black cherry in Wisconsin and it is unknown if this incident represents the beginning of a new pest problem. Utilization of the logging slash as much as possible would be a wise practice until we learn more about this bark beetle.



Orthotomicus caelatus (Eichhoff)

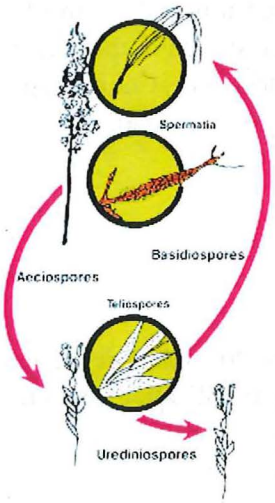
Orthotomicus caelatus (Eichhoff), a bark beetle, was observed in a Norway spruce plantation in Waukesha County (Sec. 23, T7N, R17E). Several small patches of 74-year-old white spruce showed symptoms of decline and dieback in 1999 and 2000. Mortality was occasionally observed. Close observation of declining trees showed evidence of attack by bark beetles. Many attacks appeared to be unsuccessful thus the role this bark beetle is playing in the decline and mortality is uncertain. The close proximity of this plantation to the interstate and the high prevalence of buckthorn in the understory may be contributing to decline of the stand. *O. caelatus* has been previously reported in Wisconsin but has not been commonly observed.

Comandra Stem Rust *(Cronartium comandra)*

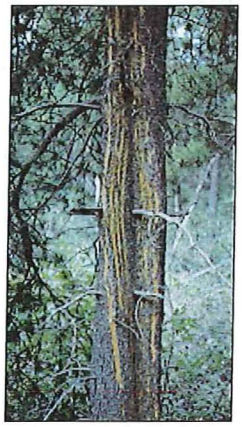
Cankering causes profuse resin production.

Comandra Stem Rust *(Cronartium comandra)* has been identified on jack pine in Adams County (SE1/4, S1/2, Sec. 22, T15N, R6E). This rust has been previously reported in Wisconsin but has not been commonly observed. Damages to jack pine caused by stem rust fungi in general include the following: reduced growth, cankers, mortality (by girdling and/or stem breakage), and creation of entry points for other fungi and/or insects. This macrocyclic rust requires an alternate host, False Toadflax or other species of *Comandra.* The number of galls on individual trees in this stand varied from 2 to over 20 per tree. Bark was missing from the galls and heavy pitch flow in the galled region was common in late summer and fall. Often small mammals such as squirrels and porcupines will chew the bark off (figure on next page). This disease is scattered in this stand of oak and jack pine and known infected trees will be removed during a planned thinning operation.

Comandra blister rust is a disease of hard pines (jack pine in Wisconsin) that is caused by a fungus growing in the inner bark. It causes the greatest economic damage in the western United States but is seen elsewhere. The fungus (*Cronartium comandrae* Pk.) has a complex life cycle. An obligate parasite, it requires two types of living hosts to survive. It grows perennially in the inner bark of hard pines and develops annually on the stems and leaves of herbaceous comandras. Like white pine blister rust, *Cronartium comandrae* cannot spread directly from pine to pine.



The fungus produces five types of spores: spermatia, aeciospores, urediniospores, teliospores, and basidiospores. The spermatia and the aeciospores are produced on hard pines; the others are produced on the alternate host.



Sqirrels commonly feed on bark infected by stem rusts.

As with white pine blister rust, most infections begin on the branches and spread toward the trunk. If the branch dies before the fungus reaches the trunk, the fungus also dies. The farther a branch infection is from the trunk, the less chance that the fungus will reach the main stem, form a canker and kill the pine.

Proportion of Forest Land and Timberland

The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at almost 16.0 million acres, representing 46% of the total land area. The state now has the most forest land it has ever had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 84% of the total timberland area classified as hardwood forest types. The primary hardwood forest type in the state is maple-basswood (Figure 1), which makes up 5.3 million acres (34%) of Wisconsin's timberland area. Conifer types represent 16% of the total timberland area (pine forests - 8%, spruce-fir - 6%, and swamp conifers - 2%).

Wisconsin timberland increased by 940,000 acres between 1983 and 1996.

- 1968 - 14.54 million acres
- 1983 - 14.76 million acres
- 1996 - 15.70 million acres

Timberland is defined as forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development.

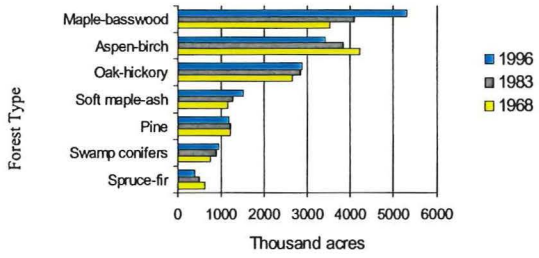


Figure 1. Area of timberland (in thousand acres) by forest type for 1983 and 1996. Data taken from 1996 FIA survey.

Ownership of Wisconsin's Timberland

Individual private landowners are the largest group of timberland owners in Wisconsin, owning 57% of all timberland in 1996 (Figure 2). counties and municipalities are the largest group of public owners, holding 15% of the total area of timberland in Wisconsin. The percentages of ownership have remained relatively constant since the forest inventory in 1956.

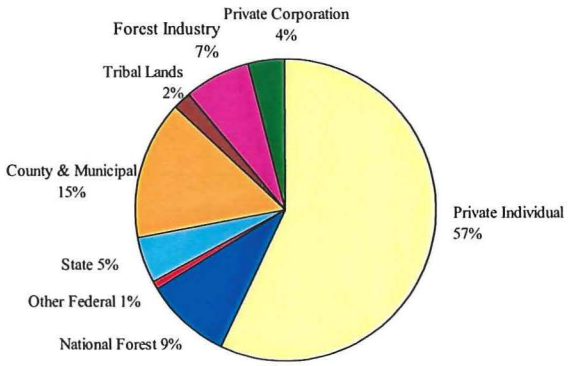


Figure 2. Ownership of Wisconsin's forests. Data taken from 1996 FIA survey.

Growing-stock Volume of Wisconsin's Timberland

Growing-stock volume on timberland in Wisconsin increased from 16.5 billion cubic feet in 1983 to 18.5 billion cubic feet in 1996 (Figure 3), reflecting an increase in both area and stocking during the 13 years between inventories. In both 1983 and 1996, hardwoods accounted for $^3/_4$ of all growing-stock volume.

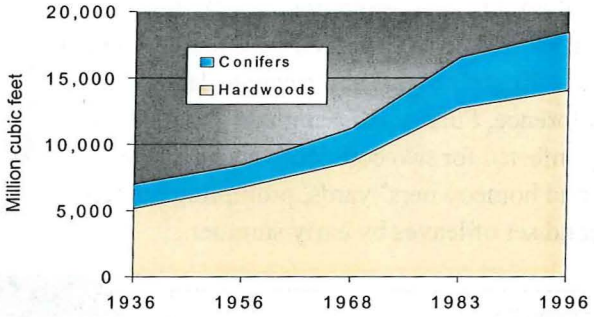


Figure 3. Growing stock volume (in million cubic feet) on timberland in Wisconsin, 1936-1996. Data taken from 1996 FIA survey.

Most Common Species Groups of Wisconsin's Timberland

The species groups with the most growing-stock were aspen, red oak, hard maple, and soft maple (Figure 4). The conifer species groups with the most growing-stock in 1996 were red pine and white pine.

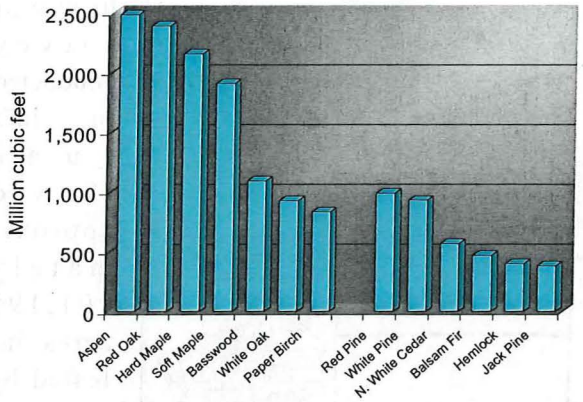


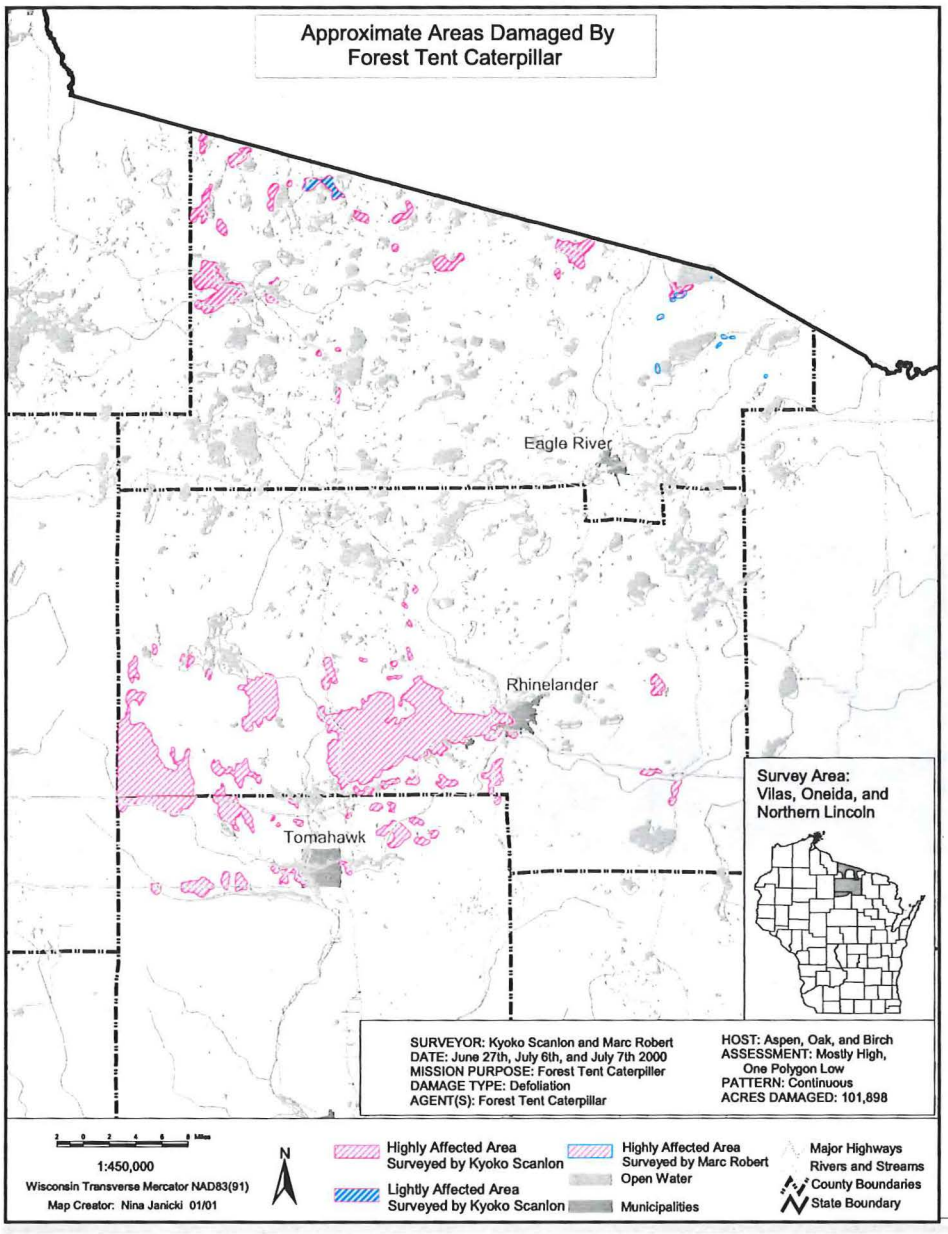
Figure 4. Most commonhardwood and conifer species (in million cubic feet) on timberland in Wisconsin. Data taken from 1996 FIA survey.

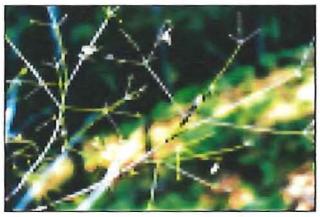
Forest Tent Caterpillar

FTC is distinguished by white keyhole-shaped spots on its back.

In 1999, populations of forest tent caterpillar started to rise in Iron and Oneida counties when approximately 48,000 acres were defoliated. The last major outbreak occurred from 1987 to 1993 spreading from northeast to northwest Wisconsin. In 2000, scattered heavy defoliation on oak, aspen, ash, birch and crabapple trees was observed in Lincoln, Oneida, and Vilas counties. Reports of migrating caterpillars were also received from Florence, Forest, and Langlade counties. Some areas have been infested for two consecutive years. Sites with heavy defoliation included downtown areas and homeowners' yards, prompting numerous phone calls. Defoliated trees produced a second set of leaves by early summer.

Forest tent caterpillars crawling on walls.





Defoliation tends to be fairly complete with all except major veins and petioles consumed.

Millions of moths were also spotted in late June to early July in many parts of northern Wisconsin, especially in downtown areas and gas stations where lights were on at night. An aerial survey conducted in late June showed approximately 101,195 acres infested by forest tent caterpillars in Lincoln, Oneida and Vilas counties. Outbreaks typically last 3 to 6 years. Although diameter growth may be reduced by as much as 90 percent, few trees are killed.

Forest tent caterpillars cluster in groups, but do not form tents.

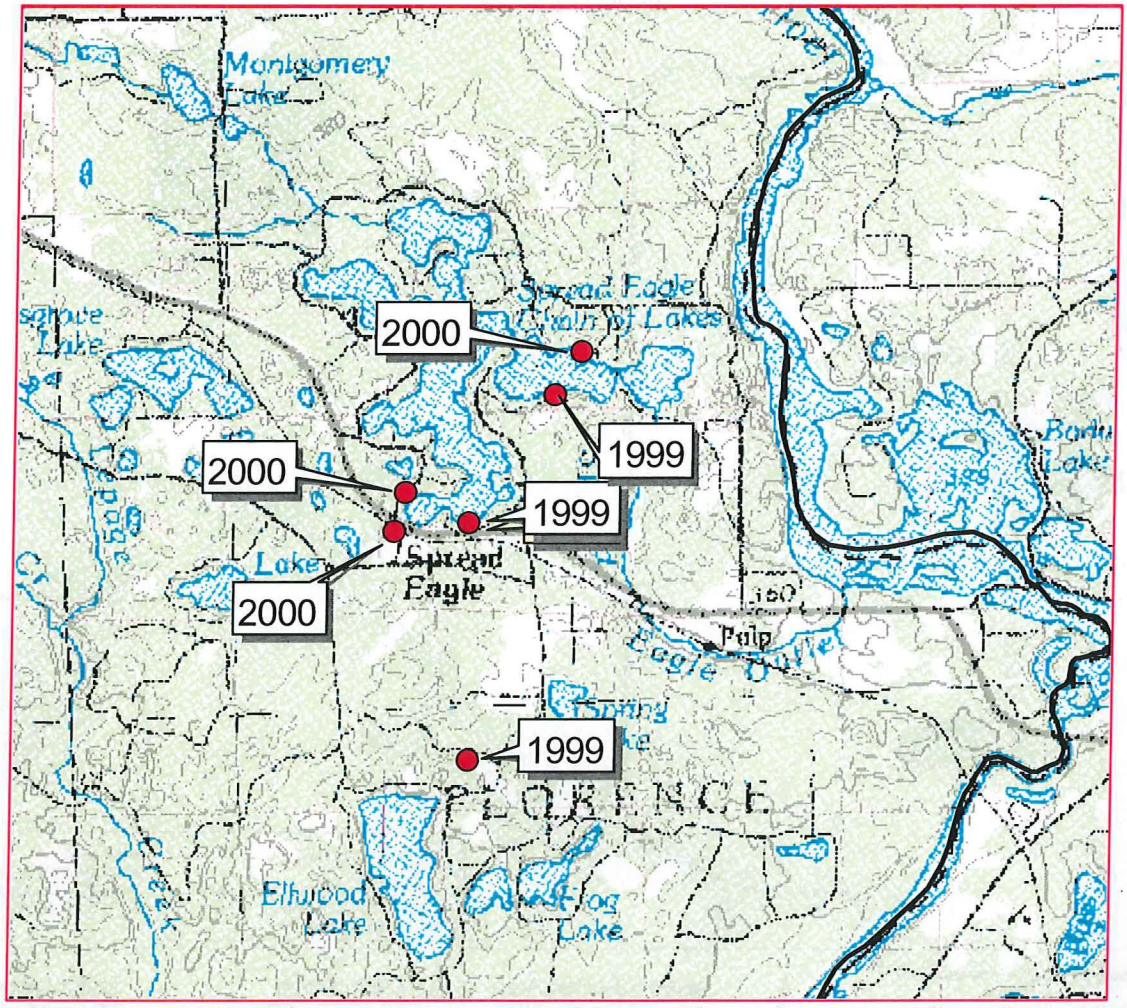
Oak Wilt

No new counties reported the presence of oak wilt in 2000. Efforts on oak wilt focused on a survey on the developing pockets in Florence County, continuation of the survey of oaks pruned in southern Wisconsin by Alliant Energy and supporting the passage of PSC 113. In July of 2000, the Public Service Commission passed administrative code PSC 113, which restricts pruning and cutting of oak in counties with oak wilt during April 15 - July 1. The code applies to electric utilities regulated by the PSC, which includes investor-owned and municipal utilities. Coop-run utilities are not regulated by PSC. The code can be viewed by accessing the PSC website www.psc.state.wi.us clicking on PSC 113 and searching for 113.0511. The code has also been published in the Administrative Register # 535 dated July 31, 2000.

Oak wilt county distribution as of 2000.

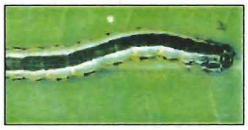
Emphasis on management of oak wilt continues to focus on prevention through limiting cutting and wounding of oaks during the high risk period from April 15 to July 1 and local spread management through root graft disruption, sanitation of infectious material and occasionally the use of a fugistat.

More oak wilt pockets were found this summer in Spread Eagle, Florence Co (see map below). All of the new sites were located within one mile of the sites detected last year. The presence of oak wilt in Florence Co. was first confirmed in 1999.



Oak wilt pockets in Spread Eagle, Florence County

Fall Cankerworm



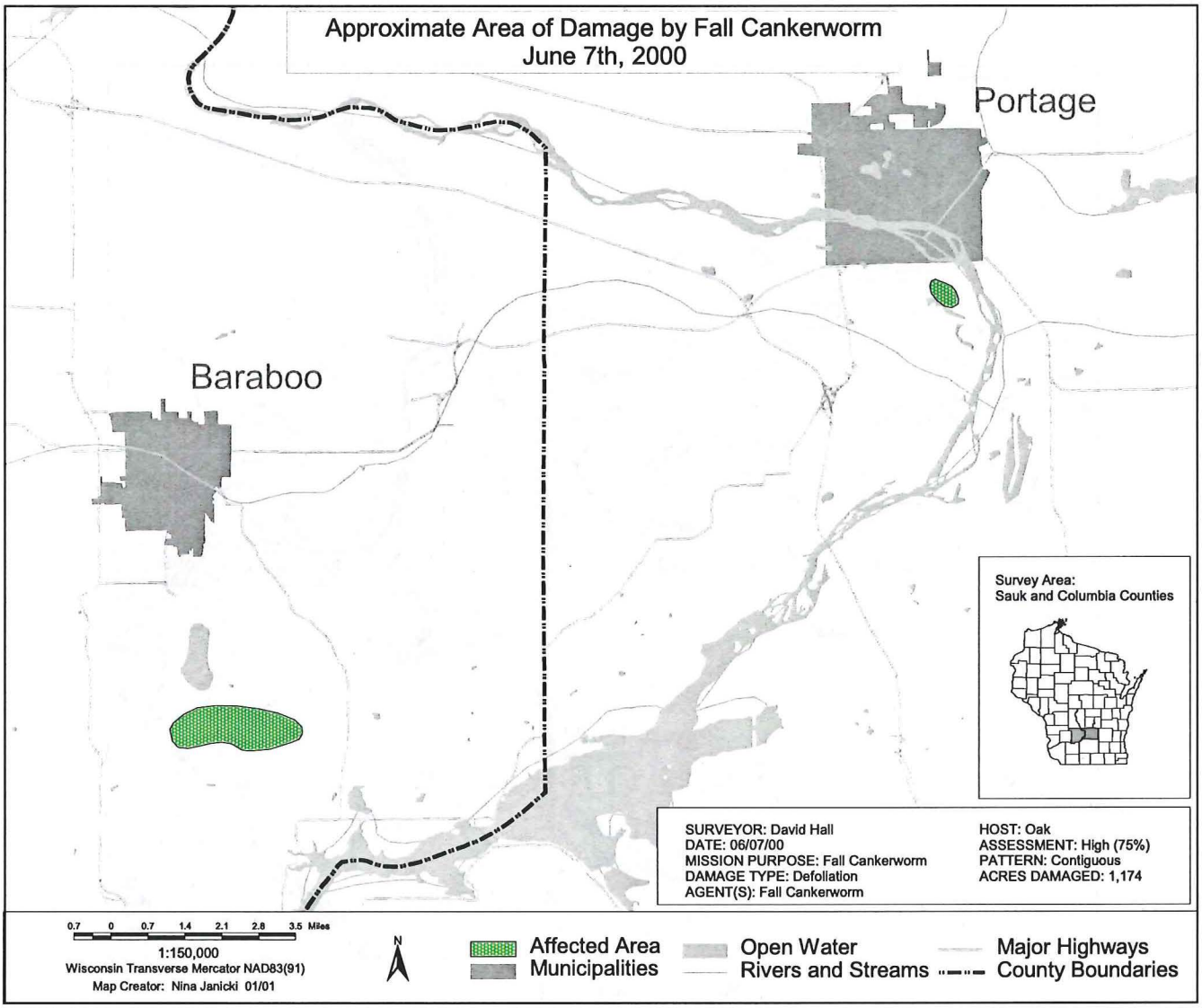
Fall cankerworm larva

The fall cankerworm (*Alsophila pometaria*) caused light defoliation of hardwoods over a large area of south central Wisconsin and pockets of heavy defoliation of oaks on dry sites in Sauk and Columbia counties. More defoliation spread over a wider area is expected in 2001.

Hosts include the red and white oak groups, maples, elms, hickories, ash, and cherry. Heavy defoliation usually occurs in May and June, and can cause growth loss, mast reduction, and, if coupled with other stresses, may result in mortality. Outbreaks are most often localized and usually last three to four years before natural control factors cause the population to collapse.Their greatest impact is often felt in high public use areas where defoliation reduces the aesthetic value, and larvae and their droppings create a nuisance.

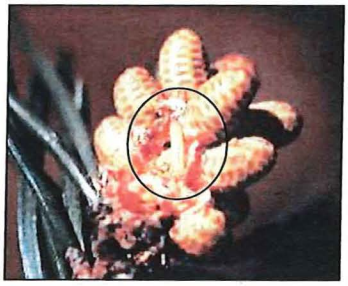
Female moth laying eggs.

The first noticeable sign of an infestation is small "shot-holes" in the young leaves. At this time the tiny larvae are found on the underside of the leaf. As the larvae continue feeding, the holes grow larger, until almost all of the leaf tissues are eaten or skeletonized.



Jack pine budworm

No defoliation was reported in northwest Wisconsin. Early larval counts were down 81% across the entire northwestern part of Wisconsin (Douglas, Bayfield, Washburn, Burnett counties).

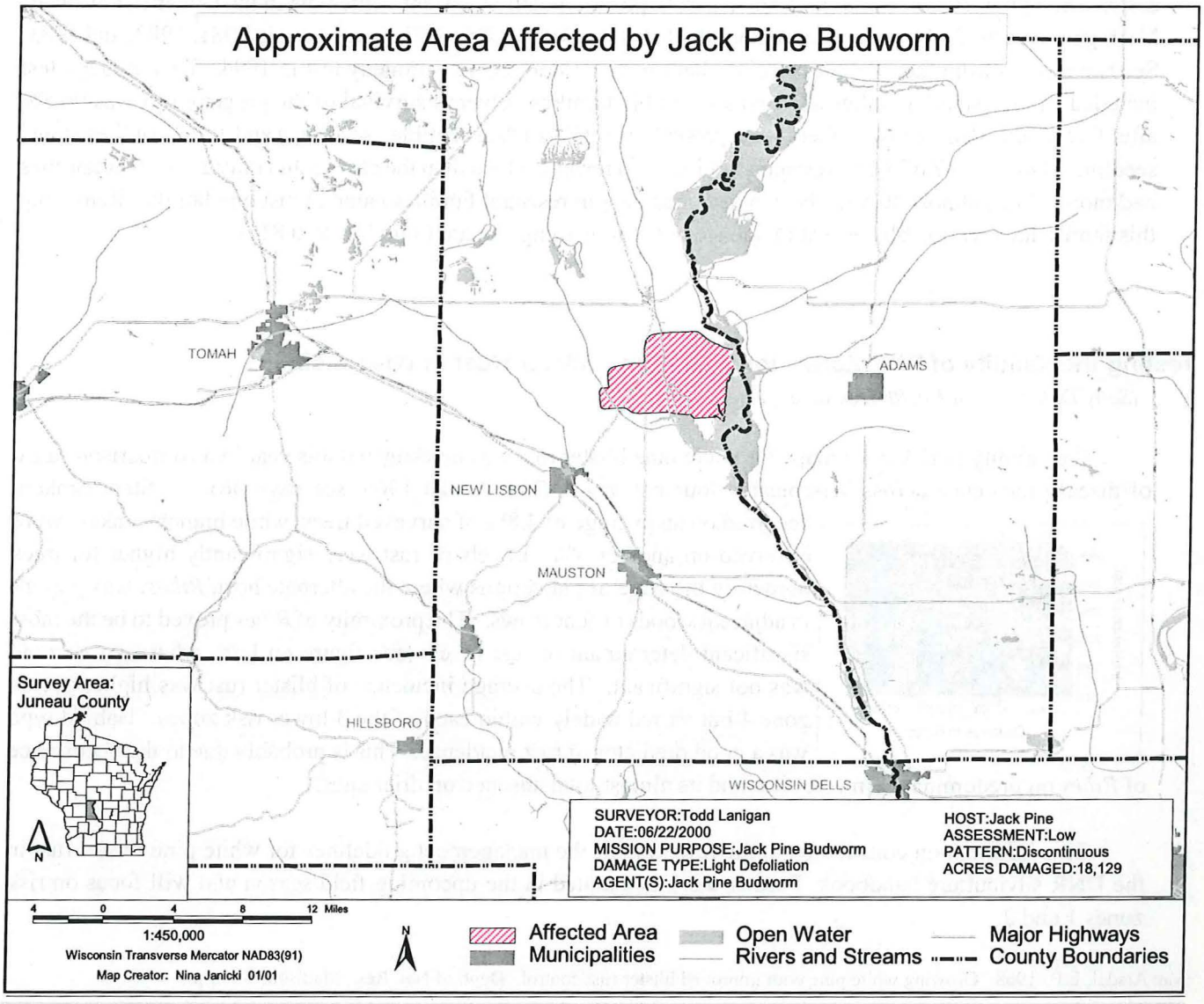


Young budworm caterpillar feeding in a male jack pine flower.

Although light defoliation occurred this year in Adams, Juneau, and Monroe counties, levels were down dramatically from the last 2 years. In Adams County, defoliation was scattered south of Highway 21. Juneau County had light defoliation south of Highway 21, east of 8th ave., and north of County Highway A. Monroe County had some defoliation southeast of Cataract and west of Fort McCoy (County Highway I, II and Delaware Ave.)

Clipped needles, frass and a pupal case collected in silk webbing

The most recent outbreak of budworm occurred in 1991-1993 in northwestern (Douglas, Bayfield, Washburn, Burnett counties), west central (Jackson, Juneau, Eau Claire, Adams, Monroe counties) and northeast (Marinette, Vilas, Oconto counties) Wisconsin. Over 400,000 acres were defoliated in 1993.



Resistance Study in Northwest Wisconsin Seed Orchard

(Shane Weber, Forest Entomologist, Spooner WI)

White pine blister rust caused by the fungus *Cronartium ribicola*, has been a major cause of mortality in North American five-needled pines during much of the 20th century. The disease arrived on infected nursery stock on the Atlantic Coast in 1912 and on the Pacific Coast about five years later. Today, blister rust is present just about everywhere white pines grow on this continent.

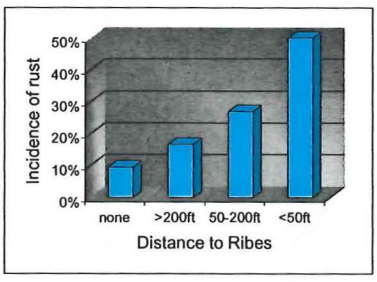
Early control efforts concentrated on destroying the alternate host (*Ribes* bushes) to break the life cycle of the disease. The next strategy involved conflict avoidance using the Van Arsdel's (1968) hazard zone maps (see pg 46). Present strategy for managing blister rust involves silvicultural measures designed to reduce the incidence and impact of the disease. While all of these management strategies are fundamentally sound, none has provided effective control of blister rust.

The current project involves trying to take advantage of the apparent natural disease resistance occurring in easter white pine (*Pinus strobus*). Branches from phenotypically resistant white pine in the Upper Peninsula of Michigan were grafted to rootstock and outplanted at the Sawyer Creek Fisheries Area in 1981, 1982, and 1983. Seeds collected from the original clonal orchard were used to create a progeny test in 1994. This progeny test included 11 "resistant" families and two susceptible families. Overall survival of the progeny test was 96.5% after five years. Blister rust cankers were present on 1.23% of "susceptible" seedlings and 1.16% of "resistant" seedlings. However, 7 of the 11 resistant families had fewer cankers than the checks and only 2 resistant families had more. Also, almost 40% of the cankers occurring in resistant families came in just one family. Removing this family lowered the blister rust incidence in the remaining resistant families to 0.81%.

Testing the Validity of Risk Zones for White Pine Blister Rust in Wisconsin

(Sally Dahir, Forest Health technician, Fitchburg WI)

The validity of risk zone maps for white pine blister rust was investigated this year in a comparison study of disease incidence across Wisconsin's four risk zones (Van Arsdel 1968, see page 46). Stem cankers occurred on an average of 4.8% of surveyed trees, while branch cankers were observed on another 3%. Levels of rust were significantly higher for trees bordering the edge of plantations where the alternate host, *Ribes*, was present in adjacent woods or fencerows. The proximity of *Ribes* proved to be the most significant determinant of rust levels (see figure on left), whereas risk zone was not significant. The average incidence of blister rust was higher in risk zone 4 but varied widely within each of the 3 lower risk zones. Habitat type was a good predictor of rust incidence. This is probably due to the occurrence of *Ribes* on predominantly mesic sites and its almost total absence on drier sites.



This information contributed to the rewriting of the management guidelines for white pine blister rust in the DNR silviculture handbook. Further work is planned in the upcoming field season and will focus on risk zones 1 and 2.

Van Arsdel, E.P. 1968. Growing white pine with improved blister rust control. Dept. of Nat. Res., Madison, WI. 4 p.

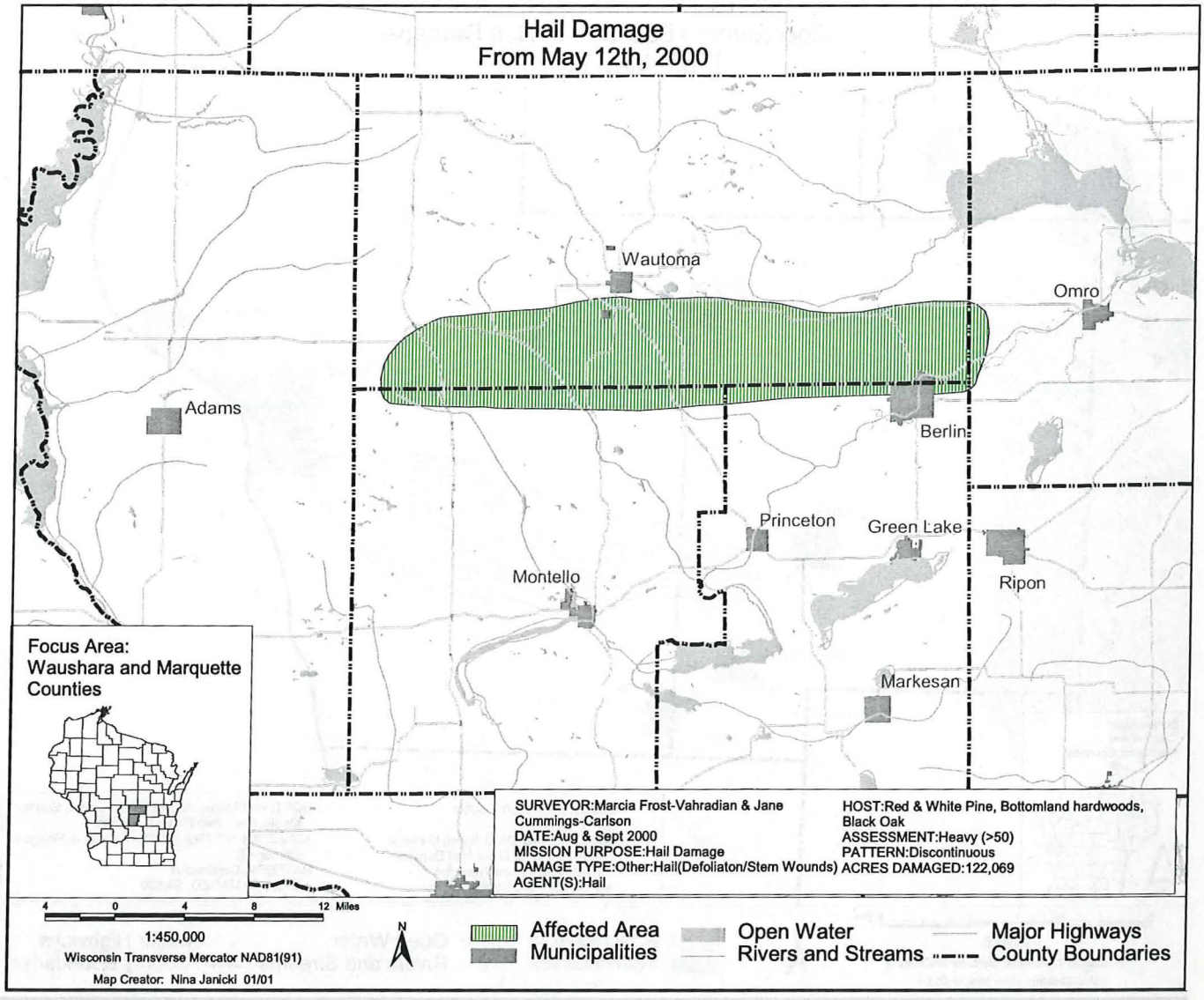
Waushara, Marquette, Manitowoc counties

On May 12, 2000, a wind and hail storm hit southern Waushara, northern Marquette and central Manitowoc counties. Meteorologists called it a thunderstorm supercell moist microburst. Golf ball-sized hail and winds up to 110 mph were reported. Damage to oak, aspen, sugar maple, red and white pine and bottomland hardwoods was scattered throughout approximately 167,000 acres. Injuries included multiple wounds and stripping of the bark caused by large hailstones. Seedling and sapling-sized trees were typically injured so brutally, they died within 2 months of the storm. Ten to twenty-year old conifers also suffered significantly and started to die late in the summer. Pole to sawlog-sized trees of all affected species were also heavily wounded by hail.

Wind damage on red pine.

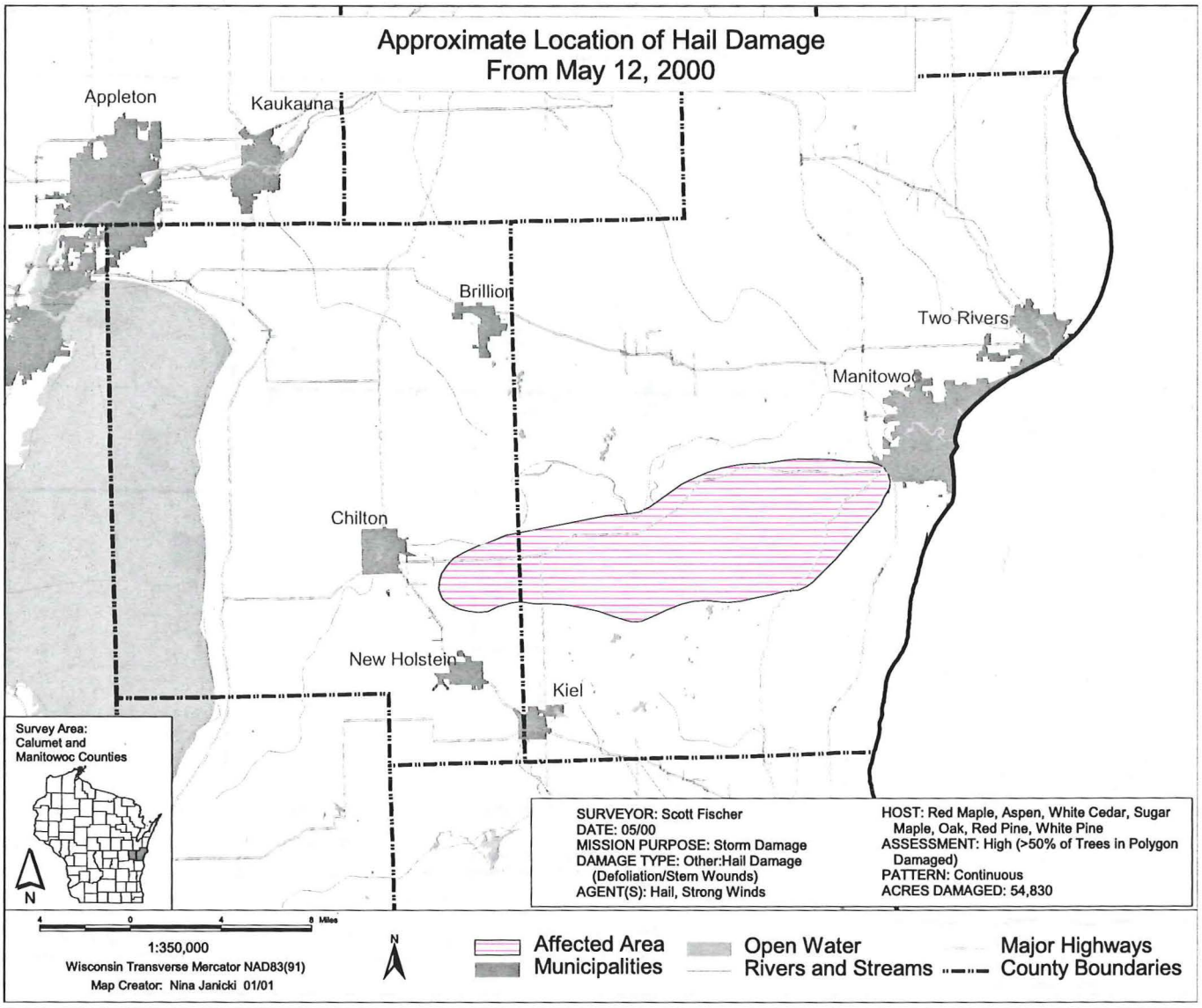
Red and White Pine

Red pines, particularly in the 20-40-year old age class desiccated quickly and browning foliage was commonly



observed 2 months after the storm. Many of these affected red pines are expected to die within the next year. The fungus, *Sphaeropsis sapinea*, known to proliferate on hail-damaged red pine, was **not** observed on these trees. The trees probably dried out and died too quickly for this fungus to become established. Younger red pine (10-12 years-old), on the other hand did show signs and symptoms of infection by *Sphaeropsis sapinea* 2 months after the storm. Infected red pines that do survive will be faced with the threat of dieback and cankers initiated by *S. sapinea.* Plots have been established in Waushara County to follow the development of *S. sapinea* and any other insect or disease problems that may develop in hail-damaged trees. In Manitowoc County, Pete Wagner, private forestry consultant, collected data on 50 red and white pines 30-50-years-old. Data included diameter, crown class, dieback, tree age and observations of crown health. Further observations will continue on these trees in 2001. In the fall of 2000, white pines appeared to have faired the multiple injuries better than red pines. Some browning of foliage was observed but more white pines than red pines are expected to survive through the winter. The frequent rains that came throughout the summer helped prevent the build up of bark beetles. No outbreaks or significant damage from bark beetles were observed.

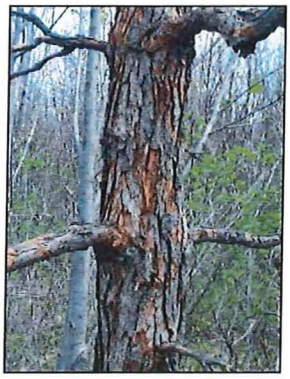
Hail damage to red and white pines, Waushara County.



Hardwoods

In Manitowoc County, the high winds caused pole to sawlog-sized hardwoods with tight codominant stems and branch unions to split. These trees now have significant wounds and will be susceptible to decay. In addition to the loss of branches and splitting of the stem, young tender buds and young foliage was stripped from the trees. Many of these trees refoliated but only produced a small number of sub-normal sized leaves. Basswood appeared to have refoliated more vigorously than sugar and red maples. Survival of these severely affected maples is expected to be low. Salvage cuts have been initiated throughout the damaged area. Bottomland hardwoods including silver maple and willow not only suffered from wind damage and hail wounds but were also injured by the large amount of rain that fell with the storm. This storm, followed by continuous rain throughout the growing season, left many bottomland hardwoods sitting in several feet of water for several months. These trees did not refoliate after the hail storm and high levels of mortality are expected in 2001.

Foliage and twig damage on black oak.



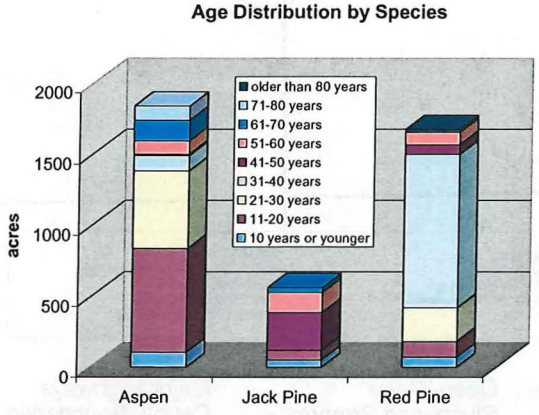
Hail wounds on the bark of black oak.

West-facing windows in many homes in the area were blown out and several barns were damaged. Straight-line winds leveled some forests, leaving trees totally stripped of their leaves and bark severely damaged by large hail. Wildlife was also reported killed in the storm. Governor Thompson declared the townships a disaster area.

Douglas County

On August 14, 2000, a similar storm, also with golf ball-sized hail, damaged timber on approximately 25,500 acres in Douglas County. Winds as high as 60 mph were recorded. The damage was scattered, not contiguous, throughout 25,500 acres and injured species included red, jack, white pine and aspen. Since this storm hit later in the growing season, buds were tougher and damage to the buds appeared to be less severe than from the spring storm in eastern Wisconsin. Other injuries included multiple stem wounds on all affected species, loss of foliage and some branch breakage. Seedlings of all species and mature jack pine are expected to suffer the highest mortality. Seedlings will suffer from multiple wounds and bark stripping. Mature jack pines do not recover well from multiple wounds and loss of foliage.

Brule River State Forest



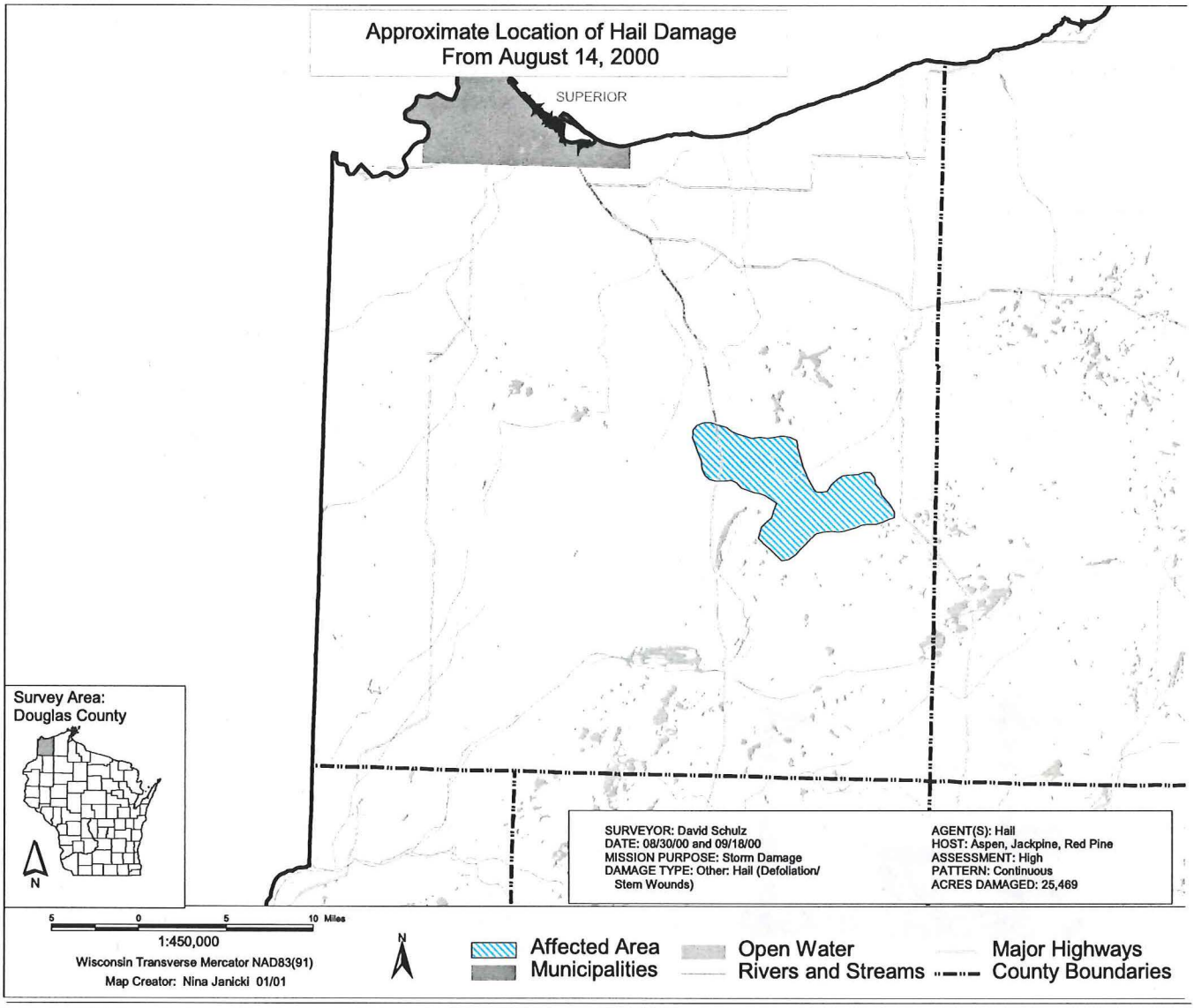
The following report on the Brule River State Forest contains information contributed by Steve Petersen and David Schulz.

An estimated 5,000 acres in the southern part of the Brule River State forest was affected by the August 14 hailstorm. The chart on the left represents acreage of affected timber by age class and species. Eighty percent of the damaged area is red pine and aspen. Nearly all the red pine and aspen is less than 40 years old and nearly all jack pine is over 40 years old. Aspen was stripped of leaves and small branches. Hail pummeled the trunk and shredded the bark on many trees. Saplings and small pole-sized trees were

girdled. Larger aspens were severely wounded but not girdled. Prognosis for the aspen includes sprouting of moderately wounded trees and full recovery of trees with superficial wounds.

Red pine seedlings were severely wounded and are not expected to recover. Red pine saplings and pole-sized trees suffered multiple wounds and broken leaders. The fungus, *Sphaeropsis sapinea* is expected to invade these injured trees and cause shoot and branch mortality. This fungus also causes branch and stem cankers over time and will influence the long-term health and form of the red pine. Older and larger red pines (>20 years old) also incurred multiple wounds, branch and leader breakage. *Sphaeropsis sapinea* is expected to infect and grow rapidly in these damaged trees, causing shoot and branch mortality. Soil moisture over the next 2 years will greatly influence the potential for bark beetle infestations of these weakened trees. Drought will encourage both the growth of *S. sapinea* and infestation of trees by the bark beetles *Ips. spp.* Plots have been established on the Brule River State Forest to follow the development of injured species and detect the development of pine bark beetle or *S. sapinea* outbreaks.

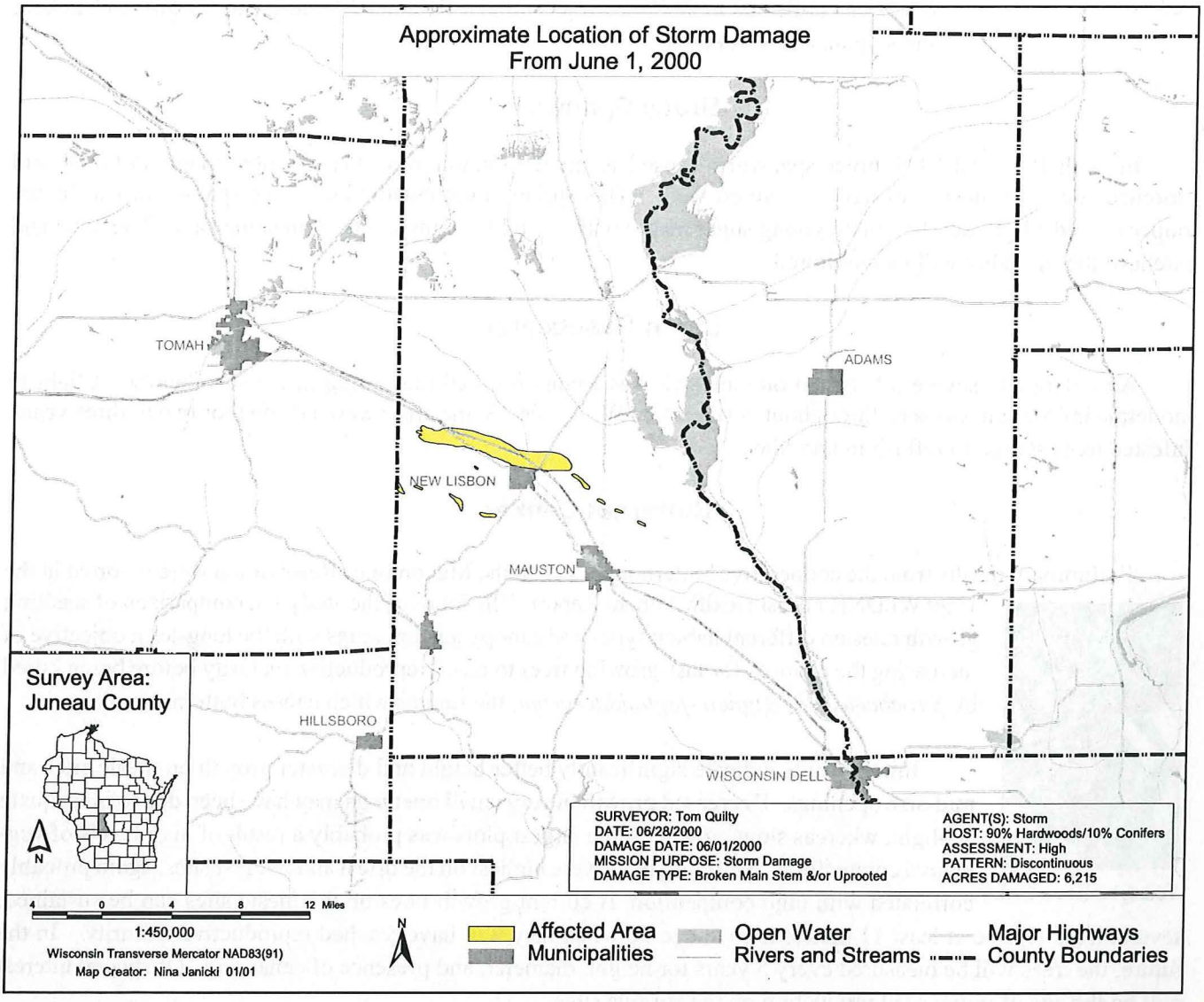
White pine showing stem wounds from hail.



Affected jack pine incurred the same injuries as red pine but is expected to decline and die more quickly than red pine. Cones were also stripped from mature jack pines, impacting the seed source for regeneration. The majority of jack pine is older than the red pine (>40 years old) and jack pine has historically shown less ability to recover from major impacts such as hail storms and heavy defoliation. Widespread mortality of jack pine in late 2000 and 2001 is expected. Brule River State Forest staff is addressing this prognosis and mature jack pine is scheduled to be harvested during the winter of 2000-2001. Following the harvest, an anchor-chain treatment will be used to scarify the sites to prepare a seedbed for natural jack pine re-establishment. If natural seeding is not sufficient, a follow-up application of additional jack pine seed may be necessary.

Juneau County

High-speed straight-line winds also ripped through central Juneau County, just north of New Lisbon, on June 1, 2000. Hardwoods, including oak and aspen were damaged through main stem breakage or uprooting. Approximately 90% of the damaged trees were hardwoods and 10% conifers (white and red pine). The path of the storm covered approximately 6,215 acres. Damage was discontinuous throughout the affected area. Salvage efforts were initiated immediately and are ongoing.



Minor Issues

Ash Yellows

Ash yellows, caused by a phytoplasma, was confirmed in two new locations in the forests of Wisconsin this year. This disease was observed initiating decline and killing large pole to small sawlog white ash trees in a 5-acre woodlot in Ozaukee County. Brooms or masses of densely clustered branches were common on infected trees. The presence of these brooms has not previously been a common sign of infection in Wisconsin's forests. Ash yellows was also confirmed in Calumet County. This stand was a privately-owned woodlot with a mix of ash, sugar maple and black cherry. Symptoms such as thin crowns, chlorotic leaves, epicormic branches and brooms were common in the stand.

Broom caused by ash yellows.

Known county distribution of ash yellows.

Ash yellows is a relatively recently discovered disease and is caused by a phytoplasma. This organism invades the tree's phloem and causes dieback and eventual mortality. These two new locations bring the total observations to six. Ash yellows has now been confirmed in the following counties: Calumet, Marathon, Manitowoc, Ozaukee, Sheboygan, and Waukesha.

Bruce Spanworm

In both 1998 and 1999, bruce spanworm caused severe defoliation in pockets of sugar maple in Forest and Florence counties; most trees have recovered well. This spring, a combination of bruce spanworm and linden looper caused a light defoliation on young sugar maple with mortality of mature trees in some sites. The level and extent of the mortality will be monitored.

Larch Casebearer

A moderate to severe infestation on tamarack was again observed this spring in Oneida County. A light to moderate infestation was seen throughout northeastern Wisconsin. Some areas were infested for two to three years. Infested trees started to reflush in late May.

Butternut Canker

Preliminary results from the cooperative butternut project on the Menomonee Reservation were reported in the 1999 WI DNR Forest Health Annual Report. The focus of the study is a comparison of seedling growth rates on different habitat types and canopy gap openings with the long-term objective of increasing the chances for fast-growing trees to reach reproductive maturity before being killed by *Sirococcus clavigigneti -juglandacearum*, the fungus which causes butternut canker.

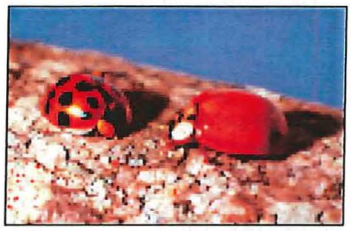
Young butternut canker

Initial results indicate significantly better height and diameter growth on mesic sites and mid-size openings. Decreased growth in very small openings may have been due to inadequate sunlight, whereas slow growth on the largest plots was probably a result of high levels of vegetative competition. Mortality rates were highest on the driest and poorest sites, again probably correlated with high competition. If current growth rates on the mesic sites can be sustained, several trees will be at least 11 meters high at age 20 when they will have reached reproductive maturity. In the future, the trees will be measured every 5 years for height, diameter, and presence of cankering. Of special interest will be the age of initial seed production on the various sites.

Multicolored Asian Lady Beetle

An imported species of lady beetle, the multicolored Asian lady beetle, was prominent this fall throughout Wisconsin. One important factor in the exceptionally high numbers seen this year may be the introduction into the state of the soybean aphid which subsequently provided a large food base for this predatory beetle. Many aphid species were heavily attacked by both the larval and adult stages of this beetle.

In the fall this lady beetle species sometimes congregates on the sides of house and on porches or in garages. The beetles are attracted to bright-colored surfaces. They may be drawn to a particular house because of the color of the exterior or the house may be in their flight path as they leave nearby trees. From the exterior of the house, they may move indoors by crawling under defective weather stripping or by crawling and flying in open doors on warm days. The beetles can fit through very small gaps or cracks in siding, masonry, around window and door casings, and even through attic vents.



The beetles hibernate as adults, usually in wall voids (they cannot survive long in the heated rooms of a house). On warm days, they may become active and move towards light or bright surfaces. The beetles are often found on windows, light fixtures and ceilings. The multicolored Asian lady beetle does not reproduce indoors. In spring, they will move outdoors in search of prey. Fortunately, multicolored Asian lady beetles are not harmful to people or pets. They do not bite or sting.

The Wisconsin DNR received many calls from concerned homeowners. Aphids which ran out of food in the late fall started tasting people which was not well received by those who were bitten. An additional complaintincluded orange staining in houses from the beetles. Multicolored Asian Lady Beetles exude some of their blood through the joints of their legs when they are threatened. Things that threaten these beetles include being squished, being sprayed, and being harassed. Vacuuming and promptly disposing of the vacuum bag is the easiest way of controlling them once in your home.

European Buckthorn (*Rhamnus cathartica)*

-This exotic brush species continues to invade oak woodlots in the southeastern and south central counties where it displaces many species of native wild flowers and under story shrubs and prevents reproduction of native tree species.

European buckthorn
(Rhamnus cathartica)

Native to Eurasia, european buckthorn was introduced to North America as an ornamental shrub. It reachs a maximum height of 25' and trunk diameter up to 10". Distinguishing characteristics include twigs tipped with spines and leaves with a dark gloss on the upper surface. Leaves stay green late into the fall, after all other leaves have fallen.The fruit is a black berry which causes a severe laxative effect, quickly distributing the seeds through birds.

Common buckthorn invades mainly woodlands and savannas, although it may also be found in prairies and open fields. Once established buckthorn crowds or shades out native shrubs and herbs, often completely obliterating them. Control consists mainly of prescribed burning in the spring plus cutting and herbicide stump treatment in the latesummer and fall.

Other Pests Reported in 2000

Pest	Host	Damage	Location
Ash			
Anthracnose *(Gnomoniella fraxini)*	Green ash	Leaf margins browning	Brown, Shawano, Outagamie, Kewaunee Co's
Ash plant bug *(Tropidosteptes amoenus)*	Green ash	Stippling and premature leaf drop. Heavy early population that dropped off rapidly	Washburn county
Ash Yellows	Green ash	Decline, dieback, death	Calumet Co.
Mountain ash sawfly (Pristiphora geniculata)	Mountain ash	Defoliation is far below normal this year	Northwest Wisconsin
Spring Frost Damage	Ash	Leaves hard hit by late May frost.	Chippewa and Eau Claire counties
Aspen			
Aspen blotch miner *(Phyllonorycter spp.)*	Aspen	Moderate to severe mining damage	Florence, Lincoln, Oneida Counties
	Quaking aspen	Moderate scattered mining	Sawyer, Price, Rusk and Bayfield counties
Forest tent caterpillar *(Malacosoma disstria)*	Crab apple	Defoliation	Urban Green Bay
Basswood			
Introduced basswood thrips *(Thrips calcaratus)*	Basswood	Light to moderate defoliation.	Scattered in West Central Region
		Light defoliation	Florence, Forest Counties
Birch			
Birch leafminer (Fenusa pusilla)	White birch	Present but not the amount of damage is much less than normal	NW Wisconsin
Black Walnut			
Walnut caterpillar	Black walnut foliage	This late-summer hairy caterpillar caused heavy defoliation of mature trees.	Columbia and Dane counties
Spring Frost Damage	Black Walnut	Leaves hard hit by late May frost.	Chippewa, and LaCrosse counties

Pest	Host	Damage	Location

Butternut

Butternut canker *(Sirococcus clavigignenti-juglanda cearum*	Butternut	Main stem and branch cankers. Some trees produced nuts.	Scattered in West Central Region
Spring Frost Damage	Butternut	Leaves hard hit by late May frost.	Chippewa

Cherry

Eastern tent caterpillar *(Malacosoma americanum)*	Wild Cherry Flowering Crabs	Defoliation	Scattered in West Central Region
		Slightly above average populations	Washburn, Burnett, Barron and Polk counties
Promethea moth *(Callosamia promethea)*	Black cherry	Heavy defoliation on young trees	Oneida County
Uglynest Caterpillar (Archips cerasivorana)	Wild Cherry	Defoliation - entire saplings were covered with silk webbing.	Eau Claire County

Christmas Trees

Balsam twig aphid *(Mindarus abietinus)*	Balsam fir	Heavy feeding/discoloration	Oconto Co.
Fir needle rust *(Uridinopsis spp.)*	Balsam Fir	Brown needles/branches scattered throughout trees.	Chippewa County
Repeating spruce needle rust *(Chrysomyxa weirii)*	Colorado blue spruce	Moderate to severe infection. Pustules on previous-year needles.	Lincoln County
Spider mites *(Oligonychus ununguis)*	Balsam Fir, Spruce	Discolored foliage, webbing along branches	Scattered in West Central Region
Unknown	White Spruce	Terminal leader, branches, and needles twisting, turning, and curling. On some trees, the entire tree has these symptoms, and on others, it's just part of the tree.	Chippewa County
White pine weevil *(Pissodes strobi)*	White Spruce	Leader mortality.	Chippewa County

Crab Apple

Fire Blight (Erwinia amylovora)	Flowering Crab	Branch mortality	Pepin County

Elm

Dutch elm disease *(Ophiostoma ulmi)*	Elm	Branch flagging to tree mortality of pole size trees.	Marathon County

Hickory

Hickory Bark Beetle *(Scolytus quadrispinosus)*	Shagbark hickory	Mortality of small - large sawlog sized hickory	Dane County

Pest	Host	Damage	Location
Larch			
Larch needlecast *(Mycosphaerella laricina)*	European larch	About 70% defoliation occurred on c. 50% of trees	Lorraine township, Polk County
Spider mites *(Oligonychus ununguis)*	Larch	Defoliation and needle discoloration. This could be the third year in a row for defoliation because of the mite population.	Clark County
Maple			
Fall webworm *(Hyphantria cunia)*	Tag alder	Common but less prevalent than normal	Sawyer, Bayfield, Price, Rusk, Ashland counties
	Various hardwoods	Defoliation and webs in trees.	Scattered in West Central Region.
Flooding	Red Maple	Decline	Green Bay
Gall mites *(Eriophyid mites)*	Red maple Sugar maple	Maple bladdergall mite (Vasates quadripedes), maple spindlegall mite (V. aceriscrumena), and /or erineum gall mite (Aceria elongatus) were prominent	Forest, Langlade, Oneida Counties
Maple bladdergall mite *(Vasates quadripedes)*	Red Maple	Leaf galls	Chippewa County
Maple leafrolle *(Sparganothis acerivorana)*	Sugar maple	Light infestation	Forest County
Maple petiole borer *(Caulocampus acericaulis)*	Sugar maple	Light defoliation	Forest, Langlade, Lincoln Counties
	Red maple Sugar maple	Leaf drop	Oconto Co.
	Sugar Maple	Leaf drop.	Rusk County
	Sugar Maple	Substantial leaf drop but no real damage	Washburn, Sawyer counties
Woolly Alder Aphid *(Prociphilus tessellatus)*	Silver Maple	White woolly insects flying around and/or on leaves. Honeydew dripping down on vehicles, decks, etc. and sooty mold forming on those various surfaces.	Scattered in West Central Region.
Oak			
Anthracnose	White oak	Leaf damage	Many counties in the NER
	Red Oak	Browning and curling of leaves.	Wood and Juneau counties
Forest tent caterpillar *(Malacosoma disstraia)*	Aspen, R Oak	Defoliation	LaCrosse, Pepin, and Portage counties
	Buildings	Moth emergence in large numbers covered homes and buildings at night - nuisance .	Clark, Marathon and Portage counties.
	N. Red Oak	Complete defoliation but reflush was prompt and vigorous	Sugarcamp township, Oneida County
June beetles	Oak	Complete defoliation by adult beetles	Shawano, Outagamie Counties
Kermes scale *(Kermes spp.)*	Red Oak	Twig dieback on saplings.	Jackson County
	Red Oak	Moderate twig mortality in planted saplings that had been heavily browsed by deer.	Richland County
	Scrub oak	Lower than normal	Douglas, Washburn, Burnett counties
Lecanium scale *(Parthenolecanium spp.)*	Mainly maple and oak	Shells were prominent on twigs. Twig dieback.	Florence, Forest, Lincoln, Oneida Counties
Oak apple gall *(Synipid wasps)*	Red Oak	Round galls.	West Central Region

Pest	Host	Damage	Location

Oak (continued)

Oak lace bug *(Coryathuca arcuata)*	Bur oak	Down overall except localized bronzing	Trego township, Washburn County
Oak leaf roller *(Archips semiferana)*	Red Oak	Defoliation	Portage County
Oak leaf tier (*Croecia semipurpurana*)	White and red oak	Defoliation	Various locations around Brown, Shawano, and Outagamie counties
Oak tatters	Red and White Oak	Abnormal leaf development.	Scattered in West Central Region.
Oak twig pruner *(Anelaphus parallelus)*	Northern red oak	Light defoliation	Oneida and Vilas counties
Oak webworm *(Archips fervidana)*	Scrub oak	Population is way down.	Entire northwest sand flats.
	Oak	Oak leaves tied together and caterpillars feeding inside.	Adams, Eau Claire, and Juneau counties.
Oak wilt *(Ceratocystis fagacearum)*	Pin oak	Death	Marinette, Brown, and Oconto counties
Spring frost damage	Scrub oak Northern red oak	Forest in late May caused light to severe damage. Some scrub oaks were completely defoliated. Heavily damaged trees refoliated.	Florence, Lincoln, Oneida counties
	All oaks	Severe damage, Leaves killed up to 50% recovery, Strange red color of reflush. Excellent	Washburn, Sawyer, Douglas, Bayfield
Yellownecked caterpillar *(Datana ministra)*	Bur oak	Heavy defoliation of sapling treesS	Dane County

Pine

Aphids *(Cinara spp)*	Jack Pine	Large numbers of aphids feeding, causing general decline of saplings with sooty mold present.	West Central Region.
Armillaria root rot *(Armillaria mellea)*	Multiple species	Declining and dying trees	Door Co.
	Jack and Red Pines	General tree decline and some mortality to seedlings and saplings.	Clark and Jackson counties.
Gall Rust *(Cronartium spp)* *(Endocronartium spp.)*	Jack Pine	Some tree mortality, but mostly causing branch mortality. Some stands are heavily infected. The gall rust causing these problems could either be Eastern or Pine Pine Gall Rust.	Scattered in West Central Region.
Ips bark beetles *(Ips spp)*	JackPine Red Pine	Tree mortality.	Scattered in West Central Region.
Jack pine budworm *(Choristoneura pinus)*	Jack Pine	Defoliation	Budworm is very scarce in Clark, Eau Claire, and Jackson counties. Light defoliation in Adams, Juneau, and Monroe counties.
Pine Gall Weevil *(Podapion gallicola)*	Red Pine	Spindle shaped galls on branches.	Portage County
Pine needle rust *(Coleosprium spp.)*	Red pine	Light to moderate infection	Lincoln County
	Red Pine	Red pine seedlings (2-0 stock, planted in 1999) were loaded with fruiting bodies on the needles.	Wood County

Pest	Host	Damage	Location

Pine (continued)

Pine root tip weevil *(Hylobius rhizophaqus)*	Red Pine	Scattered branch flagging in trees.	Adams and Jackson counties.
Pine Spittlebug *(Aphrophora cribrata)*	Jack and White Pine	Feeding on trunk and branches of trees.	Scattered in West Central Region.
	White pine	Frothy spittlemasses on trees	Oneida County
Pine tortoise scale *(Toumeyella parvicornis)*	Jack Pine	Yellowing of foliage, heavy sooty mold, and general decline of trees.	Wood County
Redheaded Pine Sawfly *(Neodiprion lecontei)*	Jack Pine	Defoliation of saplings.	Jackson County
	Red pine	Light defoliation	Oneida County
Red pine pocket decline	Red Pine	Tree mortality and general decline of trees.	Scattered in West Central Region.
Red pine shoot moth *(Dioryctria resinossella)*	Red Pine	New shoots killed, trees did set bud behind the dead shoots.	Scattered in West Central Region.
Red Turpintine Beetles *(Dendroctonus valens)*	Red Pine	General decline of trees.	Scattered in West Central Region.
Salt & drought damage	Red and White Pine	Needle burn and general decline of trees.	Scattered in West Central Region.
	Red pine White pine	Needle browning, chlorosis, and loss	Scattered throughout the Headwaters Basin
Sphaeropsis collar rot and shoot blight *(Sphaeropsis sapinea)*	Scotch Pine	Browning needles	Door County
	Red Pine	Shoot and branch flagging. Some trees are heavily infested.	Clark, Portage and Trempealeau counties
	Red Pine	Seedling mortality: seedlings planted too deep in heavy soils and excessive rain all contributed to the stress and mortality from collar rot	Clark County
Spring Frost Damage	Jack Pine	Terminal leaders and lateral shoots wilted/wilting from late May frost.	Scattered in West Central Region.
White Pine Aphid *(Cinara strobi)*	Red Pine White Pine	Large numbers of aphids feeding, causing general decline of saplings with sooty mold present.	West Central Region.
White Pine Weevil *(Pissodes strobi)*	Jack Pine	Dying terminal leaders with shepherds crooks.	Jackson and Juneau counties
Zimmerman Pine Moth *(Dioryctria zimmermani)*	Jack and White Pine	Pitch masses near branch whorls. larvae feeding in the tree	Scattered in West Central Region.

Pest	Host	Damage	Location

Spruce

Cooley Spruce Gall Adelgid	Blue spruce	Galls on twigs	Shawano Co.
Cytospora canker *(Leucostoma kunzei)*	Blue Spruce	Branch death	Shawano
Eastern spruce gall adelgid *(Aldelges abietis)*	Spruce	Light infestation	Langlade, Oneida Counties
Lirula needlecast *(Lirula macrospora)*	Spruce	Needle necrosis on 2-3 year-old needles	Langlade County
Spruce needle rust *(Chrysomyxa spp.)*	Spruce	Light to moderate infection. Pustules on current-year needles	Forest, Oneida, Vilas Counties
Rhizosphaera needlecast *(Rhizosphaera kalkhoffii)*	Blue Spruce	Needle loss	Door Co.

Tamarack

Larch casebearer *(Coleophora laricella)*	Tamarack	A light to severe infestation	Scattered throughout Headwaters Basin.

Willow

Gray Willow Leaf Beetle *(Pyrrhalta decora decora)*	Willow	Leaf feeding.	Dunn, St. Croix, and Wood counties
Imported willow leaf beetles *(Plagiodera versicolora)*	Willow	Moderate to severe feeding damage	Lincoln, Oneida Counties

Miscellaneous Pests

Euonymos caterpillar	Euonymos species	Complete defoliation and complete webbing	Green Bay, Manitowoc
Honey Locust Plant Bug	Honey Locust	Defoliation & curling twigs	Appleton, Green Bay
Peach Leaf Curl	Peach	Leaves severely deformed	Manitowoc Co.

Abiological Factors

Hail Damage	All species	Stripped leaves, severely damamged bark,	Manitowoc Co.
Lawnmower	Various species	Girdling wounds at base of tree	Multiple sites

Forest Health Monitoring

Jane Cummings-Carlson
Forest Pathologist

CHANGES COME TO FHM IN 2000!! This year, the FHM plot program merged with the long standing Forest Inventory and Analysis (FIA) plot program. This merge allows greater efficiency in data collection and will strengthen our ability to describe the forest resources of our state. Future efforts related to interpreting FHM data will be linked to what the FIA database can contribute.

Forest health monitoring (FHM) developed from growing national concerns about the effects air pollution, acid rain, global climate change and population growth were having on our forest resources. FHM is designed to determine on an annual basis, the status, changes, and trends in indicators of forest condition. FHM uses data from ground plots to detect changes in indicators such as crown dieback and foliage transparency and focuses research on determining the factors influencing these changes. In Wisconsin, this project is in its 7th year and is accomplished with a unique partnership between a nonprofit organization - Lumberjack Resource Conservation and Development, WI DNR and the USDA Forest Service. This cooperative effort has the following components: **Detection Monitoring, Evaluation Monitoring and Intensive Site Ecosystem Monitoring.**

Detection Monitoring is the most extensive of FHM's three monitoring activities. It is designed to provide data to determine base line or current conditions of forest ecosystems, and detect changes and trends over time. This information is analyzed to determine if detected changes are anticipated, and if those changes indicate improving forest health or are cause for concern, warranting additional evaluation. Detection monitoring covers all forested lands and has two components the Plot Component and the Survey Component.

The Plot Component[1]

There are a total of 93 permanent FHM plots in Wisconsin, with approximately 37 being evaluated each year. This number of plots is too small to give significant information about the status of Wisconsin's forests. Future efforts will focus on increasing the number of plots that have FHM data parameters measured. Plot data can be analyzed at the regional level.

The basis for the FHM plot component is a network of permanent plots distributed on a systematic grid across the entire U.S. Measurements or groups of measurements called indicators are collected yearly on the plots. An indicator is defined as any biological and non-biological component of the environment that quantitatively estimates the condition or change in condition of ecological resources, the magnitude of stress, or the exposure of a biological component to stress. The current set of indicators being measured in the plot component of detection monitoring include: mensuration, crown condition, damage assessment, ozone bioindicator plants, vegetation diversity, lichens, and soils.

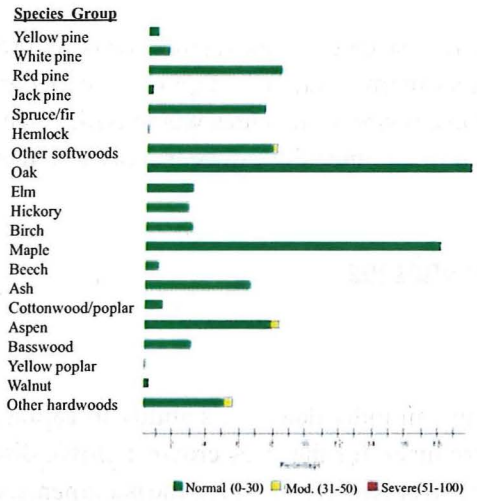
The Survey Component

The symptoms of natural and human-caused stressors that affect forests are detected and measured with aerial and ground surveys. Important stressors are insects, diseases, climate changes, extreme weather, and air pollution. Commonly measured symptoms include defoliation, foliage discoloration, tree dieback, branch breakage, main stem breakage, uprooted trees, and tree mortality.

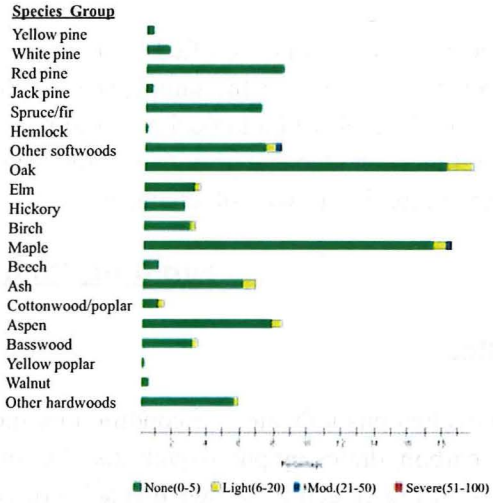
[1] Please see subsection on the plot component to read more about plot design and data collection procedures.

Conclusions from 1999 Data From 11 States in the Central Region

Forest health monitoring is a long-term program to determine base line or current conditions of forest ecosystems, and detect changes and trends over time. The plot component of the program has proved useful in establishing baseline data for forest health on a regional - multistate basis. We now have seven years of forest health monitoring plot data. Forest health monitoring plot data indicates that the Lake States forests, including Wisconsin are generally in good health. Foliage transparency and crown dieback figures indicate that our forests are within the normal range of a healthy forest.



Foliage transparency by species



Crown dieback by species

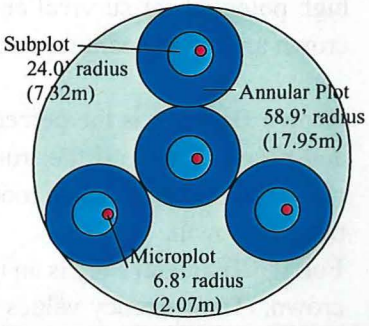
FHM Plot and Sampling Design Details

FHM Plot Design

Each FHM plot has four fixed-area, circular subplots. Subplot centers are spaced 120 feet (36.6m) apart. All subplots are 1/24-acre (1/60 hectare) in size and contain a micro-plot offset 12 feet (3.7m) from the subplot center. The micro-plots are 1/300-acre (1/750-hectare) in size.

Most tree measurements are taken within the subplots. Seedlings and saplings are measured on the micro-plots. Annual plots are used for the tree measurements that require collecting a physical sample. This allows the subplots to remain unaltered by sample collection.

FHM Sampling Design



The FHM sampling design is a spatially and temporally systematic sample on a national hexagonal base grid located 27 km apart. The sampling design minimizes the number and frequency of plot visits without reducing precision to an unacceptable level.

Rotating panel and interpenetrating design are related and non-interchangeable terms describing the FHM design. Rotating panel means that a specific group of plots (a panel) is measured at a specified frequency (for example, ev-

ery four years). Interpenetrating design describes how the plots are grouped into panels – the FHM plots in any panel are chosen so they are uniformly distributed within the monitoring area. Each level – the base grid, the panel, and the overlap – is an equal area sample of the same geographic area. This means that for a given level, each plot represents the same number of acres. All plots are equidistant from all adjacent plots.

Forested plots on the base grid are measured on a four-year cycle with 1/4 of the plots (called a panel) measured every year. In addition, 1/3 of the plots from the previous years panel (called the overlap) are measured. This overlap is 1/12 of the base grid. When the design is implemented for the first time, all plots are established and measured the first year. This complete measurement provides an estimate of initial status and improves precision in estimating change in forest health within two years after the entire base grid is established.

The design can be easily modified to meet more stringent or less stringent data requirements as program objectives evolve. For example, the sample size can be increased either permanently or temporarily in geographic areas that have high levels of biological or anthropogenic (human-caused) stress. In states where policy decisions require greater precision than that provided by the national grid, the sampling intensity can be increased in that state without losing compatibility with other states.

Forest Health Indicators - Definitions

Crown Ratings

Crown evaluations indicate tree condition by indirectly assessing an individual tree's ability to capture light and produce carbohydrates by photosynthesis. Six measurements are made for the trees crowns; crown diameter, live crown ration, crown density, crown dieback, crown transparency and crown vigor. These measurements, except for crown vigor, are made on all live trees 5.0 inches diameter at breast height and larger. The measurements for live crown ration, crown density, crown dieback and crown transparency are assigned range from 0 to 100 percent, by 5 percent classes. FHM field crews collect crown data during the normal field season that begins in early June and ends in early September.

Crown Diameter requires two measurements, one at the widest point and a second diameter measurement made 90 degrees to the diameter at the widest point. If viewed from the air, the crown diameter is the average of an oval including all foliage.

Live Crown Ratio is the percentage of height which supports live, green foliage that is contributing to total height growth.

Crown Density is a measure of how complete an individual tree crown is when compared to a full-crown outline. Crown density represents the amount of foliage, reproductive structures (seeds and cones), and branches that obstruct skylight visibility through the crown. Trees with high scores for crown density generally have high potential for survival and reproduction. Crown density values greater than 20% indicate more active crown areas and healthier trees, values less than 20% indicate poor crown condition.

Crown Dieback is the percentage of recent branch mortality that begins at the terminal portion of branches and proceeds toward the trunk, excluding portions caused by natural shading or competition. Dieback is caused by severe shock to root systems, drought or disease. Some species show natural light dieback as part of normal growth.

Foliage Transparency is an indicator of light filtering through needles and leaves in the upper one-third of the crown. Transparency values differ by species and depend on natural branching habit and foliage orientation.

High transparency values (>50%) indicate unhealthy crown conditions. Reduce foliage can be caused by insects disease and other stressors.

Damage

Pathogens, insects, air pollution, and other natural or human disturbances all cause damage and can adversely affect the health of the tree and ultimately the forest. The FHM program collects data on up to three instances of damage per tree, limiting observations to certain types of damage, which may potentially kill or adversely affect the trees long-term survival. For each tree the location and an assessment of the degree of severity are also recorded. Types of damage include; cankers, conks, open wounds, resinosis, dead tops / loss of apical dominance, broken limbs, branches and roots, brooms, damaged foliage, and discolored foliage.

Air Pollution

The effects of air pollution on forest ecosystems are evaluated regionally in the FHM program in three ways: ozone bioindicator plant evaluation; lichen community analysis focusing on sulfur and nitrogen sensitive species; and soil chemistry analysis evaluating soil pH and exchangeable Ca, Mg, and K.

Ozone Bioindicator Monitoring

Ozone bioindicator plants are vascular plant species (herbs, shrubs, or trees) that are highly sensitive to ozone air pollution and respond with distinct foliar injury symptoms that can be diagnosed under field conditions. Ozone bioindicator plants are evaluated on or near the FHM plots in suitable openings (>0.5 acre) where the appropriate ozone-sensitive plant species are found. Plots are scored as positive or negative for ozone injury. The severity of ozone injury at each plot is also recorded.

Lichen Monitoring

Lichens are fungi that live in intimate association with algae. Lichens are very responsive to environmental stressors in forests, including changes in forest structure, air quality, and climate. In FHM, data is collected on epiphytic lichens, those growing on trees and shrubs. Because the effects of air pollutants on trees can be difficult to separate from other influences on growth, epiphytic lichens provide a clear indication of potential air quality impacts on total forest productivity.

Lichen community measurements are made within a 120-foot-radius circle centered on each FHM field plot. Additional data can be collected from urban and industrial sites to help define lichen community response to air pollution in each region. FHM crews are trained to collect a sample of each species found and record the relative abundance of each species. Lichen experts do the actual species identification.

Soil Chemistry

Soil morphology (physical characteristics) and chemistry indicators of ecological condition are used in FHM to evaluate the below-ground portion of forest ecosystems. Measurements will be made of A, E, B, or C mineral horizons as deep as 40 inches from the soil surface, including any overlying O horizon (organic horizon) and forest floor deposits.

Results, Comments, and Locations of Annosus Root Rot (Heterobasidion annosum) Aerial and Ground Survey's 2000

Mark Guthmiller
Wisconsin Department of Natural Resources
Forest Health Management

Prior History

- 1993- First annosum infection center found (Adams Co.)
- 1994- Second annosum infection center found (Iowa Co.)
- 1998- Third annosum infection center found in same Iowa Co. stand
- 1999- Intensive ground surveys of the two Adams and Iowa Co. annosum infected stands was conducted. No new infection centers found in Adams County. Two new infection centers found in Iowa Co.
- 1999- In addition to the previous infected stands, three new infection centers were found (2 in Sauk County and 1 in Richland County)

Known locations of wn locations of Annosum root rot - 2000.
Annosum root rot - 2000

Aerial Survey

Aerial survey photo of potential annosum pocket.

An aerial survey of a 10 mile perimeter from know annosum infected stands, including the entire Wisconsin River valley from Sauk County to Prairie du Chein was conducted in February, 2000. A total of 28 sites were located with potential "pockets" of pine mortality. A portion of these 28 sites were ground surveyed in 2000 for the presence of annosum.

Ground Survey Results

Reported "pockets" of pine mortality from DNR staff, landowners, and a portion of the pockets detected in the aerial survey were ground surveyed for the presence of annosum in the spring, summer, and fall of 2000.

- 31 infection centers were surveyed for presence of basidocarps of annosum. All 31 infection centers turned up negative for annosum[1].
- 13 of these 31 infection centers were also sampled using a root isolation technique to look for the conidial state of annosum[2]. All 13 infection centers were negative for annosum. (Small bark/wood plugs were taken from four sides of each of three severely fading or dead trees at each infection center. Plugs were taken from the bole at approximately 3-5 inches below soil line using an agar plug cutter. Plugs were place in sterile vials and plated to specialty media in the lab).
- 9 of the 13 infection centers sampled for annosum had cultures containing Leptographium species.

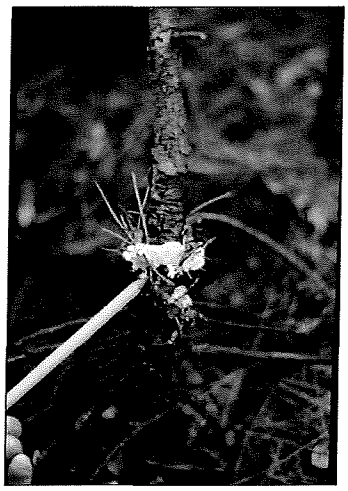
Basidiocarp (conk) of annosum under the removed duff.

Sauk County Forest 2000

- Intensive ground survey of the Sauk County Forest was conducted. A total of 51 potential infection centers (2 or more fading or dead neighboring trees) was found.
- Of the potential infection centers found, 32 were confirmed as annosum by the presence of basidocarps (31 in red pine plantations and 1 in a white pine plantation).

Survey Comments

- Don't rely solely on aerial surveys for detecting potential annosum infections centers. Many of the small annosum infection centers detected during the ground survey of the Sauk County Forest were not detected by aerial survey.
- For best aerial observation of infection centers, it would be recommended to conduct aerial surveys for annosum in early winter with snow on the ground, before many of the dead needles fall off infected trees. This would give the greatest contrast for viewing infection centers from the air.
- The best time to survey for the presence of annosum basidiocarps (conks) would be late summer and fall. It is possible to find basidiocarps from the previous year in early spring but they are often fairly deteriorated. By late spring and early summer the previous years basidiocarp (if present) will start to put on new white porous growth on the underside.
- With the exception of one white pine stand, annosum has been confirmed only in red pine plantations in Wisconsin.
- A few white pine saplings and one red oak sapling within a red pine infection center have also been attacked and killed by annosum.
- A few naturally regenerated red pine seedlings were killed by annosum in one infection center.



Small red pine seedling killed by annosum

Ground Survey Locations

County	Legal Discription	H. annosum basidocarps	Root Isolation Taken	Leptographium present
Adams	T18NR6ENWSW	No	Yes	Yes
Clark	T24NR4W5NWNW	No	Yes	Yes
Eau Claire	T25NR5WNWSE	No	Yes	Yes
Eau Claire	T27NR8W20SWSE	No	Yes	Yes
Eau Claire	T26NR6W9SENW	No	Yes	Yes
Grant	T8NR1W3NESE	No	-	-
Grant	T8NR1W11NESW	No	-	-
Grant	T8NR1W11NWSW	No	-	-
Grant	T8NR1W11SWSW	No	Yes	Yes
Grant	T8NR1W11SWSW	No	-	-
Grant	T8NR3W13NWSE	No	Yes	Yes
Grant	T8NR3W25NWNW	No	Yes	Yes
Iowa	T7NR2E1NESW	No	-	-
Iowa	T7NR4E14NESW	No	-	-
Jackson	T21NR2W35SESE	No	Yes	No
Jackson	T21NR3W32SESW	No	Yes	No
Jackson	T24NR6W3SWSE	No	-	-
Juneau	T20NR4E1SENE	No	-	-
Juneau	T17NR2E18SWSE	No	-	-
Marquette	T17NR8E20SWSE	No	Yes	No
Trempealeau	T22NR7W19NWNW	No	Yes	No
Trempealeau	T22NR7W19NWNW	No	Yes	No
Waushara	T18NR8E24SENW	No	-	-
Waushara	T19NR9E7SENW	No	Yes	Yes

Interstate 94 Survey between Black River Falls and Eau Claire		
Site number	**Mileage marker**	**H. annosum basidocarps**
DOT-1	92.90	No
DOT-2	93.05	No
DOT-3	93.20	No
DOT-4	93.15	No
DOT-5	90.90	No
DOT-6	71.80	No
DOT-7	91.50	No

Root Isolation Trial for Detection of Annosus Root Rot

Mark Guthmiller
Wisconsin Department of Natural Resources
Forest Health Management
May 2000

Introduction:

Annosus root rot, caused by the fungus *Heterobasidion annosum,* was first reported infecting red pine plantations in Wisconsin in 1993. A few additional infection centers have been found since that time. Infection centers have a characteristic "pocket" formation with dead trees in the middle and fading to dying trees around the perimeter. These confirmed infection centers are based on the presence of basidiocarps (conks) at the base of infected live and dead trees as well as stumps. Numerous additional pockets have been observed around the state but can not be confirmed as annosum infection centers due to the absence of basidiocarps. This trial was conducted to determine if sampling of known infected trees would recover the conidial state (*Oedocephalum* sp.) of the fungus in culture. If successful, this technique could then be used as an additional tool in confirming the presence of annosum in the absence of basidiocarps.

Basidiocarp (conk) of annosum showing white porous underside.

Methods:

A selective media was prepared prior to sampling using Kuhlmans media[1]. 2-dram screw top vials were autoclaved and refrigerated prior to use. A site was selected that was confirmed infected with annosum based on presence of basidiocarps. Five trees and one stump were sampled. The five trees were in various states of decline, from thinning crowns to dead with most of the needles off. Two samples were taken at three locations on each tree. Trees were sampled at the bole at 3"-5" below soil line, 6" from bole on root, and 18" from bole on root. In addition, two pairs of samples were taken from the bole of one old stump. The bole and roots of each tree were cleared of dirt with a trowel and the outer bark scraped with a knife. A layer of inner reddish bark was left intact. The sample site was then rinsed twice with 95%ETOH, letting the site dry for approximately 30 seconds between rinses. While the surface was slightly wet, sampling was done with a steel #1 agar plug cutter. The plug cutter was hand twisted through the inner bark into the wood to a depth of about ¼" and the core sample placed in a sterile vial kept on ice.

Sampling technique for conidial state of annosum.

The paired samples were returned to the lab for isolation. One sample was placed directly onto the selective media to determine if further sterilization of samples would not be necessary prior to plating. The other paired sample was surface sterilized with a 10 second dip in 95% ETOH, a one minute dip in 20% bleach, a final one minute dip again in 20% bleach, and placed on the selective media.

The plates were incubated at room temperature for 7 days, then checked for the presence of the conidial state (*Oedocephalum*) using a dissecting scope at 64x and a microscope at 200x. Methyl blue was used for slide mounts to assist in seeing the fruiting structures.

[1] Kuhlman, E.G. & F.F. Hendrix, Jr. 1962, Phytopathology 52: 1310-1312.

Tree 1 (Dead tree with 99% of needles gone-Conk Present)					
Sample #	Bole-3"-5" below soil	6" out on root	18" out on root	Positive	Negative
1		x			x
2		x		x	
3	x				x
4	x			x	
5			x	x	
6			x	x	
Tree 2 (Dead tree with 99% of needles gone-Conk Present)					
Sample #	Bole-3"-5" below soil	6" out on root	18" out on root	Positive	Negative
7	x			x	
8	x			x	
9		x		x	
10		x		x	
11			x	x	
12			x	x	
Tree 3 (Alive with thin crown, tufted but not yellow needles-Conks NOT Present)					
Sample #	Bole-3"-5" below soil	6" out on root	18" out on root	Positive	Negative
13	x				x
14	x				x
15		x			x
16		x			x
17			x		x
18			x		x
Tree 4 (Alive with thin crown, tufted but not yellow needles, resin soaked roots-Conks NOT Present)					
Sample #	Bole-3"-5" below soil	6" out on root	18" out on root	Positive	Negative
19	x			x	
20	x			x	
21		x			x
22		x			x
23			x	x	
24			x		x
Tree 5 (Alive with thin crown, 40% dead shoots-Conks PRESENT)					
Sample #	Bole-3"-5" below soil	6" out on root	18" out on root	Positive	Negative
25	x			x	
26	x			x	
27		x		x	
28		x		x	
29			x	x	
30			x		x
Old Stump					
Sample #	Bole-3"-5" below soil	6" out on root	18" out on root	Positive	Negative
31	x			x	
32	x				x
33	x				x
34	x			x	

Results:

Twenty of 34 samples (60%) were positive for *H. annosum*. Recovery rates based on sample location were as follows:

- Bole samples positive: 7 of 10=70%
- 6" out from root samples positive: 5 of 10=50%
- 18" out from root samples positive: 6 of 10=60%
- Stump samples positive: 2 of 4=50% recovery

Conclusion:

Recovery rates for annosum, approximately 60% on both sterilized and non-sterilized samples, were apparently not influenced by plating methodology. In addition, taking samples from the bole at 3'-5" below the soil, proved to give an adequate recovery (70%). This would allow for a quick sampling method by taking a plug sample from the bole and directly plating it to selective media in the lab.

The recovery rate for annosum was 60% for all samples taken. If sampling were limited to trees with shoot mortality of at least 40% (Trees 1, 2, and 5), recovery rates of annosum could possibly be as high as 80%. Although this was a small sample size, the success of recovery of annosum using this technique suggests this method may be a useful tool in detecting annosum infections in the absence of basidiocarps.

-All ODD NUMBERED samples were isolated directly on selective media with out further sterilization.

-All EVEN NUMBERED samples were sterilized in a 10 second dip in 95% ETOH, 1 minute in 20% bleach, again for 1 minute in 20% bleach, and plated on selective media.

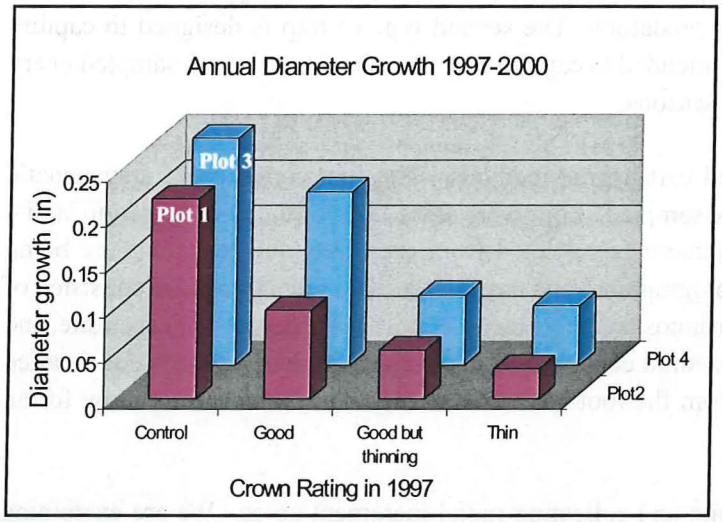
Lake Wissota State Park Red Pine Pocket Decline Study

by Todd Lannigan
Regional Entomologist
Southwest Region

A study was initiated in November of 1997 to track Red Pine Pocket Decline sites in a red pine stand in Lake Wissota State Park, Chippewa County. The plantation was established during 1957-1958. The third thinning was done from November 1996 – February 1997 using a Bobcat equipped with a hydraulic harvester and saw-head attachment.

Pocket boundaries were marked with black paint and all trees inside the pockets numbered. The dbh was measured and any damage to the trees was recorded. Crown rating was done using an arbitrary system: G (good healthy crowns), GT (good but thinning crowns), and T (thinning crowns). Good but thinning crowns (GT) crowns look healthy, but they are not as full as the good healthy (G) crowns. Thinning crowns, have very sparse foliage often with tufts of leaves at the ends of branches (lions tail)., These measurements are retaken during the dormant season.

Four control plots have also been established. Two of the plots were located near the active pocket decline sites, and two were located at some distance. One of the distant plots occurs in an area of the stand that has not been thinned.



The plots will be monitored yearly and any changes will be recorded. The monitoring will continue until the next scheduled thinning in a few years.

The chart on the left shows the disparity in growth rates between trees in the various crown quality classes. Red pine on the control plots had much higher diameter growth rates than the trees with the healthiest crowns in the pine pockets.

Insects and Pathogens Affecting Forest Health of Red Pine

UW PRINCIPAL INVESTIGATOR: Kenneth F. Raffa, Professor, Department of Entomology, UW Madison
DNR PROJECT LIAISON: Jane Cummings - Carlson
PERIOD: April 1, 1997 - May 30, 2000
BUDGET: $25,000 / yr.

BACKGROUND:

Numerous red pine plantations in Wisconsin are undergoing significant decline. The causes of these losses are not understood. There appears to be no single causal agent. Instead, a variety of insects, fungi, and site factors interact, and the relative importance of these various factors varies among sites. However, the symptoms at the stand level exhibit a rather common pattern. Affected trees are often arranged in concentric patterns. Center-most trees are dead, and adjacent trees show crown thinning. Each year, these regions increase in radius. Thin - crowned trees die, and previously healthy trees show crown symptoms..

OBJECTIVES:

The purpose of this research is to identify insects and pathogens associated with declining red pine stands, identify abiotic factors that favor their abundance and virulence, and develop monitoring methods for predicting the occurrence of potentially damaging species.

METHODS:

We conducted surveys of insect abundance, disease symptoms, and site factors in 17 plots throughout central and western Wisconsin. These included 9 declining sites, 4 control sites, and 4 control sites adjacent to declining sites.

Insects were surveyed using three types of traps: Baited (racemic ipsdienol & lanierone) multiple funnel pheromone traps (Wood 1982, Lindgren 1983, Raffa 1991), baited (+alpha pinene & ethanol) jug traps (Rieske & Raffa 1993), and baited (-alpha pinene & ethanol) pitfall traps (Hunt & Raffa. 1989). The first type of trap is aimed primarily at sampling bark beetles, wood borers, and predators. The second type of trap is designed to capture turpentine beetles and stem weevils. The third type is intended to capture root insects. Insects were sampled every 15 days during the 1997, 1998, and 1999 insect flight seasons.

Disease symptoms and pathogens were sampled using three methods. The first consisted of a systematic sampling of roots. At each of the 17 sites, 8 trees were sampled. Four were at the edge of the pocket margin, and 4 were in asymptomatic regions of the stand. Root tissue was collected from each tree, and isolations are being conducted. The main targets of this approach are Leptographium and Armillaria. The second method consisted of using red pine stem sections to sample Heterobasidion annosum. Five stem sections were deployed at each site, and at a site known to contain this pathogen. The third method consisted of excavation of plots, to allow for detailed examination of root tissue, adjacent to and distant from the root collar. This method is intended to allow for an opportunity to examine other possible causal agents.

Additional studies include: 1) Mapping each site and collecting radial increment cores. We are examining possible correlations among pocket size, tree growth rates, tree relative growth rates, and mortality; and 2) Soil analysis. These are being analyzed by the University of Wisconsin Soil and Plant Analysis Laboratory (Schulte et al. 1987).

RESULTS:

The major stem colonizing insects were Ips pini, Ips grandicollis, and Monochamus carolensis. I. pini is the most important insect in this group. The most abundant predators were Thanasimus dubius, Platysoma cylindrica, Platysoma parallelum, and Enoclerus nigripes. The major insects captured in jug traps were ambrosia beetles, Pissodes nemorensis, Orthotomicus caelatus, and Dendroctonus valens. The major insects captured in pitfall traps were Hylastes porculus, Hylobius pales, Hylobius radicis and Hylobius rhizophagous.

A major difference between declining and control stands, was that the former sites had fewer predators of bark beetles. Moreover, nondamaged portions of declining sites had predator populations more similar to the pockets than to the true controls, indicating there is something inherently different about sites that do or do not contain pockets. Temporal patterns of predator abundance are different in declining vs. healthy stands, indicating that dispersal patterns are important. Populations of root colonizing insects were higher in healthy stands early in the season, but higher in declining stands throughout much of the ovipositional period. Population modeling demonstrated strong negative correlations of bark beetles with predatorsm, both within and between seasons, at the stand level.

Behavioral studies show that bark beetle pheromonal communication varies with tree species, and that predators show equivalent relative responses. Some tree compounds inhibit beetle attraction to its own pheromones. Predators use some of these tree compounds to facilitate their attraction to bark beetle pheromones. The major predators are attracted to Ips pini and Ips grandicollis, but not to the other beetles listed above.

Direct examination of roots indicated black-staining in association with root insects, but no other pathogens. The principal fungi isolated from roots were Leptographium procerum and Leptographium terebrantis. These were more prevalent in declining than healthy stands. Staining fungi were more frequently isolated from roots of trees at the pocket margin than from trees in the asymptomatic portion of declining stands. Red pine disks were deployed in November, 1998. Heterobasidion was isolated from a site of known infection in Iowa Co., but not from other stands.

Soil samples were collected in July, 1998. There do not appear to be any significant trends.

CONCLUSIONS:

Predators of bark beetles are important in reducing pest numbers, and hence in maintaining healthy red pine stands. Site specific features appear important in supporting predator populations. Future work should emphasize identifying and fostering these site characters, and understanding factors affecting dispersal. .

The major pathogens present appear to be Leptographium, in association with root insects. This agrees with previous observations by Raffa & Hall (1988), and Klepzig et al. (1991). There is no evidence of widespread incidence of Heterobasidion. However, methods development needs further evaluation.

ACKNOWLEDGMENTS:

Paul Pimgray, Gregory J. Edge, Brian F. Marinello , Rick Livingston, Jim Skorczewski, and Paul Heimstead of the Wisconsin DNR, assisted in finding plantation study sites. Johann Bruhn, Univ. Missouri provided advice on sampling methods for heterobasidion. Glen Stanosz, Univ. WI provided advice on fungal isolation methods. Murray K. Clayton and Erik V. Nordheim, Department of Statistics, University of Wisconsin, Madison, provided statistical advice.

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PUBLICATIONS BASED ON FUNDED RESEARCH:

Erbilgin, N, & K.F. Raffa. 2000. Effects of host tree species on attractiveness of tunneling pine engravers, *Ips pini* (Coleoptera: Scolytidae), to conspecifics and insect predators. J. Chem. Ecol. 26: 823-840.

Erbilgin, N. & K.F. Raffa. 2000. Opposing effects of host monoterpenes on responses by two sympatric species of bark beetles to their aggregation pheromones. J. Chem. Ecol. 26: 2527-2548.

Erbilgin, N. & K.F. Raffa. 2001. Kairomonal range of generalist predators in specialized habitats. Entomol. Exper. et Applic. In Press.

Erbilgin N & Raffa K.F. 2001. Modulation of predator attraction to pheromones of two prey species by stereochemistry of plant volatiles. Oecologia. In press.

Erbilgin, N., A. Szele, K.D. Klepzig, & K.F. Raffa. Trap type, chirality of alpha-pinene, and geographic region affect sampling efficiency of root and lower stem insects in pine. J. Econ. Entomol. Submitted.

Erbilgin, N., & K.F. Raffa. Association of declining red pine stands with reduced populations of bark beetle predators, seasonal increases in root colonizing insects, and incidence of root pathogens. For. Ecol. & Manag. Submitted.

PRESENTATIONS BASED ON FUNDED RESEARCH:

North Central Forest Pest Workshop. Sept.1998. Effects of host tree species and chemistry on the response of *Ips pini* and its major predators to I. pini pheromones". N. Erbilgin & K. F. Raffa

North Central Forest Pest Workshop. Sept. 1998. Applying differences between bark beetle and predator responses to pheromones for population monitoring and trap-out. B.H. Aukema & K.F. Raffa.

Canadian Entomological Society, National Meetings. Nov. 1998. Applying differences between bark beetle and predator responses to pheromones for population monitoring and trap-out. B.H. Aukema & K.F. Raffa.

Entomological Society of America National Meetings. 1999. Predator Responses to Specific Bark Beetle Pheromones are Differentially Mediated by Host Plant Compounds. N. Erbilgin & K.F. Raffa.

Entomological Society of America National Meetings. 1999. Integration of biological and semiochemical control of bark beetles: Applying components of predator - prey co-evolution to minimize trap out of natural enemies B. Aukema & K.F. Raffa.

North Central Forest Pest Workshop. 2000. Rhinelander, WI. Recent research on pine bark beetles. K.F. Raffa, N. Erbilgin, B. Aukema, & K. Wallin.

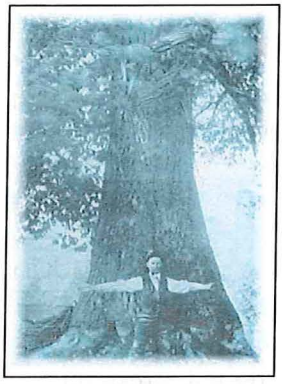
North Central Forest Pest Work Conference. 2000. Association of bark beetle predators with healthy red pine stands. N. Erbilgin & K. Raffa.

Entomological Society of America National Meetings. 2000. Effects of Predators on the Population Dynamics and Forest Impact of the Pine Engraver, *Ips pini* (Coleoptera: Scolytidae). N. Erbilgin & K. F. Raffa.

Last Stand for the American Chestnut:
West Salem, Wisconsin

by Sally Dahir
Forest Health Technician
Wisconsin Dept. of Natural Resources

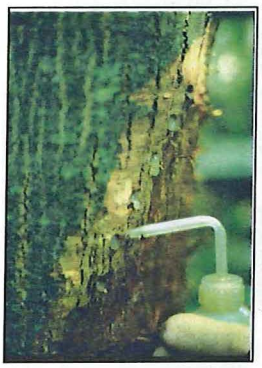
Not too long ago, the American chestnut was one of the most important trees in forests from Maine south to Florida, representing 1 out of every 5 hardwood trees. Chestnuts formed a very important part of local ecology and local economies, serving as a major food source for wildlife and people, as a source of lightweight and rot resistant lumber for anything from fine furniture to fenceposts, and finally as a major source of tannin for tanning leather. Immigrants travelling west often included a sack of chestnut seeds in their belongings to help get started in their new homestead. One of these immigrants, a farmer from Pennsylvania named Martin Hicks, planted his chestnuts on land just north of West Salem, Wisconsin. Now owned by 2 local farmers, Ron Bockenhauer (left) and Karl Rhyme, the stand has since taken off and today there are over 3,000 chestnut trees on 160 acres.



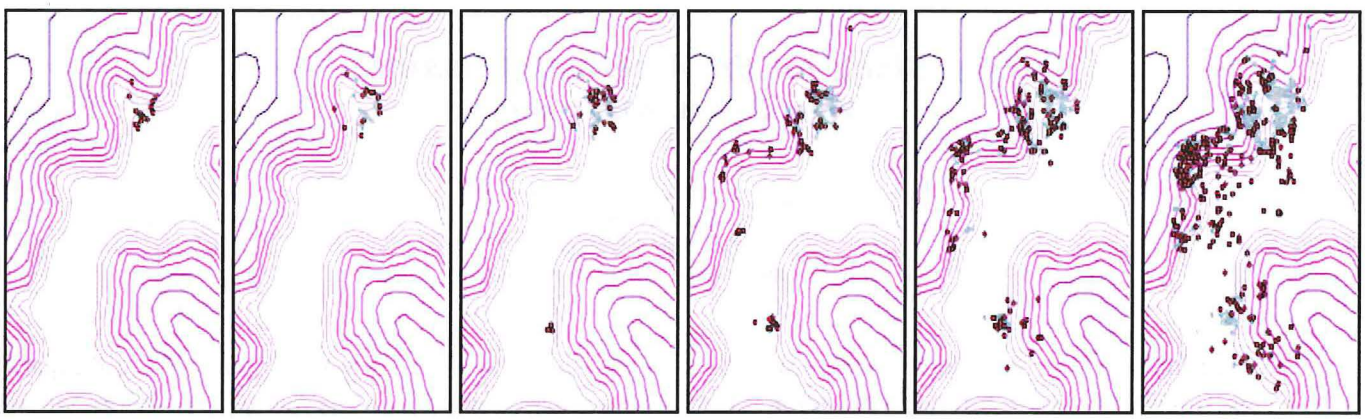
Although chestnut blight, caused by *Endothecia parasitica*, decimated eastern forests, several remnant populations escaped the disease for many years, including Farmer Hick's stand. In 1987, 4 trees died from the disease and subsequent attempts to contain the fungus such as cutting and burying trees, spraying infected trees with foam, and covering cankers with a soil-borne biocontrol agent, were unsuccessful.

In 1991, scientists from Cornell, Michigan State, and West Virginia universities decided to introduce a hypovirus to at least slow the spread of the disease. Hypovirulence was first observed in Italy where spontaneous healing of cankers was documented. These cankers contained a nonlethal or "hypovirulent" strain of *Cryphonectria.* This hypovirulence could be transmitted to normal strains of the fungus through hyphal anastomosis. Several hypovirulent isolates were found on healing chestnut trees in Michigan, where in a few stands almost all signs of blight had disappeared.

In 1992 through 1994, researchers decided to introduce the Michigan hypovirus into the stand by injecting a slurry of virus into holes punched in the living margin of cankers (right). Only one strain of the fungus was present in the West Salem stand at the time, which made the site ideal for this type of therapy. A survey in 1994, however, revealed that only 30% of treated cankers were positive for hypovirus. The strain from Michigan was so highly curative that cankers underwent rapid callus formation. Hypovirulent hyphae subsequently disappeared from canker margins, thus eliminating a source of innoculum which+ would have insured the spread of hypovirulence to other cankers.



A less virulent, more easily transmitted strain of hypovirus from Italy was introduced in 1995-1997. This pathogen has been more successful, with at least half of sampled cankers containing hypovirus. However, since 1996, new vegetative compatibility types have been discovered which are sexually compatible with the original strain. Unfortunately this will only increase the genetic diversity of the fungus and complicate efforts to slow its



1990-1991
19 trees total

1992-1993
32 trees total

1994-1995
61 trees total

1996-1997
129 trees total

1998-1999
267 trees total

2000
583 trees total

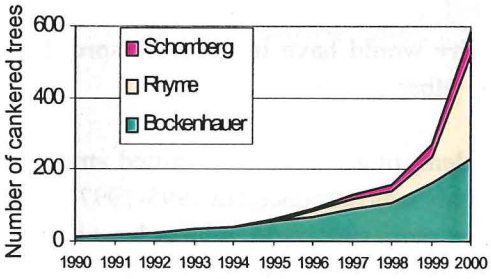
Sequential maps of cankered trees overlain on topographic lines demonstrate that the disease initially infected trees on top of the ridge and then spread outward and downhill. Notice a second disease center starting in 1994-95 to the south of the first, again on the ridgetop.

spread.

The present state of the West Salem stand

Since 1990, annual surveys have kept track of newly cankered trees, recording the number and height of cankers. In 1997, professional tree climbers were hired to sample cankers high on the stem (figure). Measures of crown dieback and transparency have been measured since 1995. Three trends seem to stand out in these surveys: 1) the annual number of newly cankered trees is increasing exponentially 2) the disease seems to be spreading outward from initial infection centers, and 3) the number of new vegetative compatibility types is increasing.

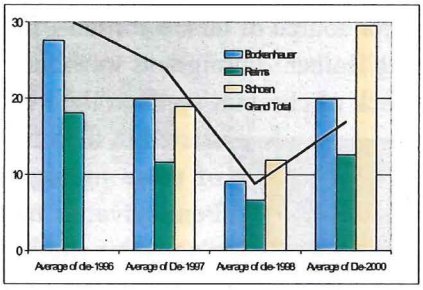
The number of newly infected trees increased linearly from 1990 to 1998 with an average 42% increase or 18 new infections per year. In 1999, however, the rate rose 70% with 109 newly infected trees and in 2000, 316 trees showed new infections for an increase of 118% over the previous year. This is obviously an exponential increase which, if it continues, could lead to a total of over 900 infected trees in 2001.



The cumulative number of infected chestnuts is increasing exponentially.

Crown dieback and transparency

Crown dieback has decreased on average since 1996 and 1997 when unusually cold winter weather may have resulted in increased stress on trees. Dieback has decreased slightly overall but increased on the Reims and Schoenberg properties where the earliest infections date from 1996 and 1995, respectively. Logically, the average dieback measured in 2000 increased with canker age except for trees with infection dating from 1990 and 1991. Several of these trees which have now had cankers for 9 to 10 years have remained around 5-10% dieback for the last 5 years.



Crown dieback has decreased on average since 1996 and 1997.

Canker spread

On the Bockenhauer and Schomberg properties, the first trees to show signs of blight were located on hilltopsand newly infected trees have generally been located downhill (figure top of page). Average elevation of trees on these 2 properties started around 296m but has now decreased to an average of 280m. On the Rhyme property, the first infections were generally on the bottom of a west-facing slope (c. 270m) but in 2000, several newly infected trees appeared all the way up the hillside.

Jack Pine Budworm Survey Procedures and Results: 2000

Shane Weber, DNR Forest Entomologist
Dept of Natural Resources
Spooner, Wisconsin

Early larval survey

This survey is done on a yearly basis and is a key indicator of the presence of destructive budworm populations. Thirty shoots and staminate flowers (15 of each) that can be reached from the ground are checked for larvae. Since staminate flowers are often scarce, a majority of shots are usually used. A count of 20 or more infested shoots and flowers is considered sufficient to cause moderate to severe defoliation.

Early Larval Populations

County	No. Plots	No. Infected Shoots	Infected Shoots/ Plots	No. High Plots	% High Plots
Polk	15	37	2.47	1	6.7
Burnett	24	26	1.08	0	0
Washburn	21	5	0.24	0	0
Douglas	53	19	0.36	0	0
Bayfield	32	3	0.09	0	0
District	**145**	**90**	**0.62**	**1**	**0.7**

Early Larval Population Trends

	No. Infested Shoots/Plot						% High Plots				
County	**1996**	**1997**	**1998**	**1999**	**2000**	**%Change 1999-2000**	**1996**	**1997**	**1998**	**1999**	**2000**
Polk	1.27	0.93	0.67	2.60	2.47	**-5**	0	0	0	13.3	6.7
Burnett	1.43	0.78	1.46	1.29	1.08	**-16**	0	0	4.2	4.2	0
Washburn	1.55	1.90	7.14	6.57	0.24	**-96**	0	5.0	28.6	28.6	0
Douglas	5.21	10.84	13.03	4.17	0.36	**-91**	18.9	60.8	81.5	9.3	0
Bayfield	6.89	13.43	7.47	1.63	0.09	**-94**	22.2	67.9	25.0	0	0
District	**3.95**	**7.29**	**7.79**	**3.32**	**0.62**	**-81**	**11.6**	**37.2**	**40.4**	**9.6**	**0.7**

Jack Pine Budworm Pupal Survey

This survey is also conducted annually and gives a good indication of the kinds and numbers of pupal parasites in the population as well as next year's population of jack pine budworm. It is done in July when most insects are in the pupal stage. Some adults may already have emerged, but empty pupal cases are collected and counted as emerged moths. At each stop, pupae are collected on a time basis. If five pupae are not found in five minutes, the collection is terminated. If five pupae are found in 5 minutes or less, the collection is continued until 25 pupae are found or until 15 minutes have elapsed. The time required to find 25 pupae is then recorded. Adults, parasites and non-emergence are recorded for each pupae.

Pupal Survey

				Moths		Parasites		Not Emerged	
County	**Total Pupae**	**Total Minutes**	**Pupae/ Min**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Polk	67	90	0.74	37	55.2	22	32.8	8	12
Burnett	27	130	0.21	18	66.7	8	29.6	1	3.7
Washburn	7	105	0.07	4	57.1	2	28.6	1	14.3
Douglas	12	265	0.05	7	58.3	5	41.7	0	0
Bayfield	1	160	0.01	0	0	0	0	1	100
District	**114**	**750**	**0.15**	**66**	**57.9**	**37**	**32.5**	**11**	**9.6**

Pupal Population Trends

County	1997 Pupae/min	1998 Pupae/min	1999 Pupae/min	2000 Pupae/min	%Change 1999-2000
Polk	0.03	0.37	0.63	0.74	+17
Burnett	0.06	0.39	0.44	0.21	-52
Washburn	0.62	1.45	0.66	0.07	-89
Douglas	1.60	1.30	0.13	0.05	-62
Bayfield	1.37	0.98	0.03	0.01	-67
District	**1.10**	**1.08**	**0.32**	**0.15**	**-53**

Jack Pine Budworm Parasite and Predator Complex

This survey involves a careful examination of all the budworm pupae collected which do not produce moths. Adult specimens are compared to a reference collection. Any unknown adults are sent to the University of Wisconsin for identification. Pupal cases from which nothing emerges are dissected to ascertain the cause of failure.

Parasite/ Predators	Total	% of Parasitized	% of Total
Itoplectes	15	40.5	13.2
Scambus	3	8.1	2.6
Phaogenes	8	21.6	7.0
Pteromalids	2	5.4	1.8
Tachinids	5	13.5	4.4
Predators	4	10.9	3.5

Techniques for Surface Creation using ArcView Mapping Software

by Sally Dahir
Forest Health Technician
Wisconsin Dept. of Natural Resources

The increasing availability and user friendliness of GPS technology and mapping software has greatly enhanced our ability to integrate spatial information in forest health research. It is now possible to identify geographic patterning in data which might previously have gone undetected. This information can then be integrated with other spatial data to create models which could be used to forecast future trends or areas of increased risk. Geostatistical modeling may be especially relevant to forest health issues. For example, risk mapping could help predict areas of severe defoliation by gypsy moth or forest tent caterpillar, or to identify sites where the incidence of diseases such as annosum root rot or white pine blister rust is likely to be elevated. Management activity could then be focussed on areas predicted to be of increased risk.

In this project, we used 3 techniques to develop predictive models, one based on interpolation of point data and two using mathematical modeling. An interpolation technique in ArcView Spatial Analyst called interdistance weighting (IDW) was used to creat a habitat type coverage of Wisconsin. Data for calibration came from the 1996 Forest Inventory and Analysis (FIA). A second technique used logistic regression to model the incidence of *Ribes* in the state also based on FIA plot data (N=5,030). Input variables were those associated with mapable plot characteristics, such as elevation, latitude and longitude, habitat type, and the ecological region, subsection or Wiscland land cover type in which the plot occurred. The third model which was used to predict the incidence of white pine blister rust in Wisconsin was based on polynomial regression. The calibration dataset consisted of survey data from a study in 1998-2000 of blister rust incidence in the state. Although the independent variables in the model were similar to those used to predict *Ribes* occurrence, because the database was substantially smaller (N=169), only a limited subset of input variables could be used.

Surface interpolation

There are several methods for interpolating surfaces with ArcView Spatial Analyst, including IDW, spline, kriging, and trend. Interdistance weighted interpolation or IDW is very useful when data points are numerous and fairly continuous throughout the area of interest. This technique assumes that each input point has a local influence that diminishes with distance and therefore weights points closer to the processing cell greater than those farther away. There are 4,133 FIA plots which were habitat-typed in 1996 and an additional 897 lowland plots which were not typed. For the purposes of this analysis, habitat types were classified by moisture-nutrient level into 9 groups based on Kotar et al. (1999): very dry, dry, dry to dry mesic, dry mesic, dry mesic to mesic, mesic, mesic to wet mesic, lowland,and Superior clay. The later was included as a separate group since the 2 habitat types represented by this group have a very distinct species composition and are limited geographically to a small region along Lake Superior.

Interpolation with IDW was used to produce a surface (Figure 1, following page) with output cell size of 1000 meters and the 12 nearest neighbors as input points in determining the value of each cell. Ecological regions are superimposed on the habitat type surface to demonstrate the strong correlation with habitat type grouping.

Since, in determining cell values, interpolation only considers the weighted value of a data point which may be at some distance from the cell, it ignores information about the area between data points, such as landtype, elevation, slope, etc. This information may have considerable contributive significance in determining cell values. For this reason, mathematical modeling may offer some benefit in that it allows the incorporation of information from other data sources.

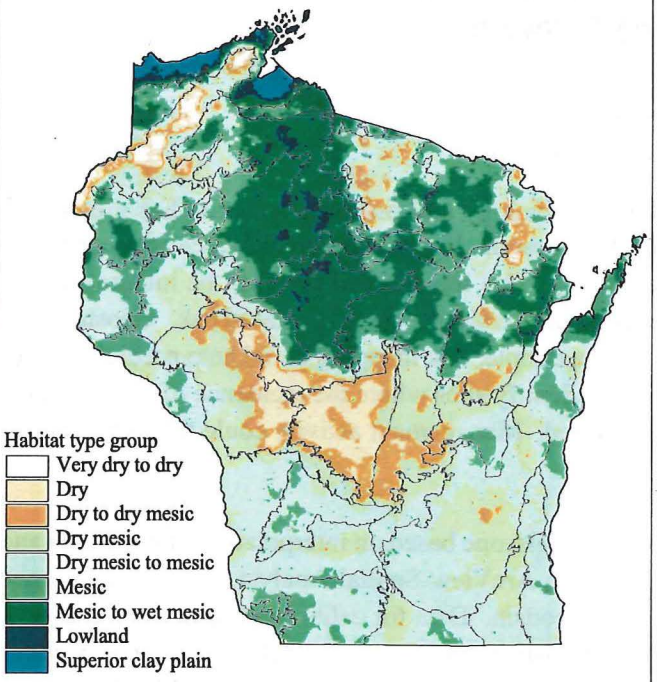


Figure 1. Surface coverage of habitat type groups created with interdistance-weighted interpolation. Ecological regions are superimposed to demonstrate the close association with habitat type.

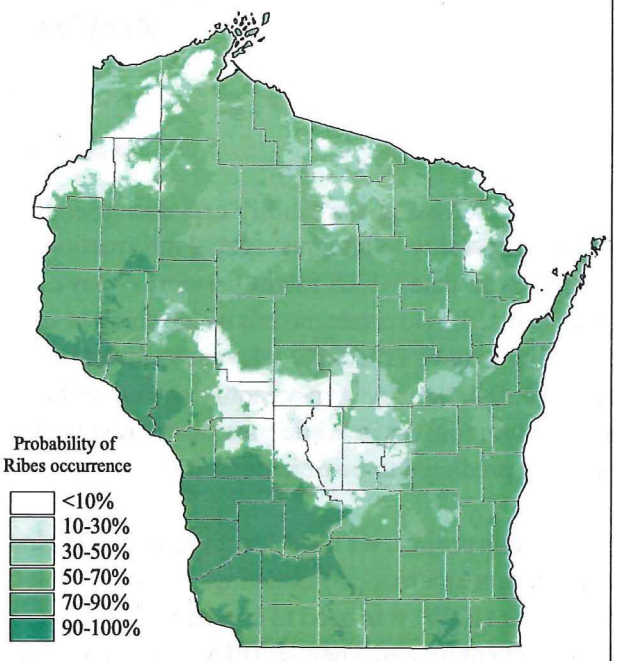


Figure 3. Surface map predicting occurrence of Ribes based on logistic regression model. Based on habitat-typed FIA plots.

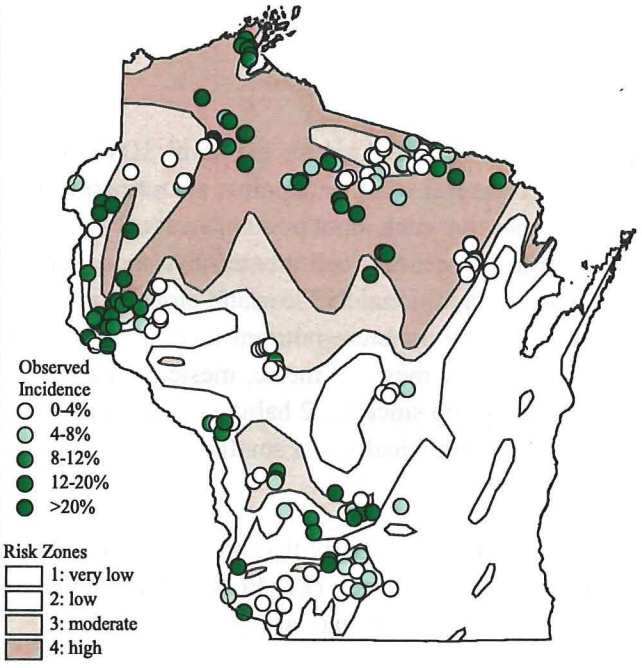


Figure 5. Observed incidence of white pine blister rust based on a study done in 1998 and 2000. Risk zone delineation is from Van Arsdel (1968, see text).

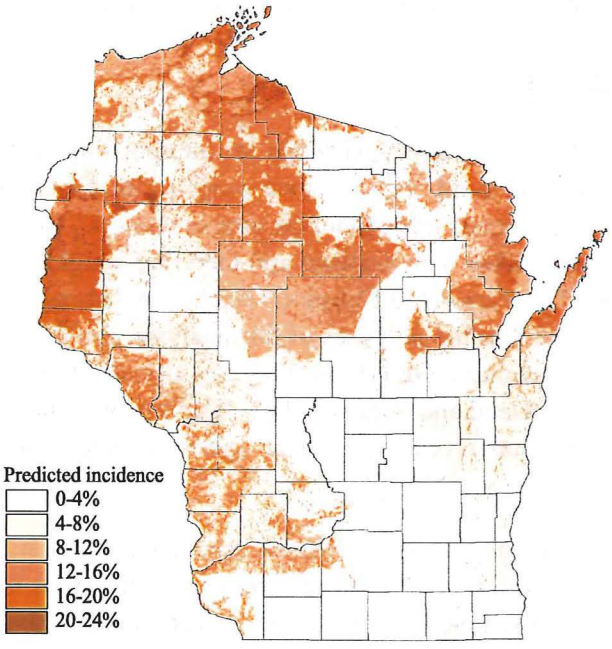


Figure 7. Surface map of predicted incidence of white pine blister rust based on polynomial regression of observed values from habitat-typed FIA plots.

Mathematical Modeling: Logistic Regression

The second method incorporated information from several data sources to create a surface predicting the occurrence of *Ribes spp* in Wisconsin. Also based on habitat-typed FIA plots, the method used a mathematical model called logistic regression to generate for each grid cell a probability of *Ribes* occurrence. During habitat typing, the presence or absence of *Ribes spp* was noted though particular species were not generally documented. It is uncertain whether all surveyors recognized or recorded *Ribes* since it was rarely a key species in determining habitat type. Since lowland plots were not typed, the occurrence of *Ribes* is unknown for these sites. Several species of *Ribes*, however, grow preferentially in alkaline lowlands in both northern and southern Wisconsin. For instance, in an analysis of historical records of *Ribes* eradication from the early to mid-1900's (Wisconsin Plant Industry, State Historical Society), 733/2,150 or 34.1% of all eradicated sites were lowlands. The exclusion of lowland plots therefore would creat an inaccurate picture of where *Ribes* was most prevalent. For this reason, *Ribes* occurrence on lowland plots was predicted based on proximity to other FIA plots where it had been recorded during habitat typing. Thus, any lowland plot located within 5 km of a plot with known occurrence was considered to also have *Ribes*. As a result, 435 or 48% of all lowland plots were assumed to have *Ribes* spp.

Logistic regression was used as the mathematical model to forecast *Ribes* occurrence. Most often used to model dichotomous (0/1 or absence/presence) data, it has the form:

[1] $$P_j = \{ 1 + \exp [- (\beta_0 + \beta_1 x_1 + \beta_2 x_2 \ ...)] \}^{-1}$$

where:

P_j = probability of *Ribes* occurring on plot i
β_i = i^{th} regression coefficient (parameter), i = 1,2,...N
x_j = j^{th} independent variable, j = 1,2,...N

One advantage of the logistic model is that the value of the dependent variable is restricted to the range 0 – 1, as the exponential term (the logit) varies between negative and positive infinity. The Likelihood ratio, which evaluates the predictive ability of the model, is dependent on the number of observations in the original dataset, and may only be used to compare models based on the same dataset. As the Likelihood ratio of a model increases, its predictive value increases. The best model will therefore be one with a high Likelihood ratio, but which also represents a biologically meaningful relationship between the independent variables and the value of the logit.

The Hosmer-Lemeshow goodness of fit test or $\hat{C}$ statistic (calculated by SAS) was also used to assess the performance of each model (Hosmer 1989). This statistic is calculated by separating the data into 10 categories of increasing probability, summing the observed (1/0) and predicted probabilities of occurrence and non-occurrence for each category and evaluating these sums with a chi-square test. The statistic has the advantage of being comparable between models based on different data sets. The distribution of $\hat{C}$ has approximately a chi-squared distribution with degrees of freedom equal to 8 when using 10 categories. The interpretation of the p-value is opposite to the standard statistical situation. In this case, the null hypothesis is the hypothesis of interest. By representing the degree of fit between estimated and observed values, the higher the p-value, the better the fit of the model under consideration, i.e. the greater the evidence in support of the null hypothesis.

Stepwise or forward regression was used with an entry p-value of 0.3. The independent variables entered in the model were ecological subsection (1000m integer grid), habitat type group (1000m integer grid), elevation (30m floating grid), latitude (1000m integer grid), longitude (1000m integer grid), Wiscland classification (30m integer grid), and subsection (1000m integer grid).

The variables in the final model are shown in Table 1 (next page). The most significant relationships were the strong negative correlations with the very dry to dry mesic habitat types and with sandy, dry ecological regions. The Likelihood ratio is 1786.6 and the percent correct prediction is 73%. The Hosmer Lemeshow statistic was 3.32 (p = 0.91, figure 2), an indication of very good correlation between expected and observed values.

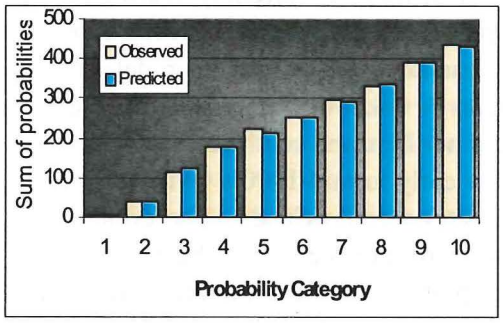


Figure 2. Comparison of the observed number of plots with *Ribes* compared to the sum of predicted probabilities by category.

In order to map the resulting equation, each grid cell in the corresponding grids was multiplied by the coefficient selected by the model. For instance, each cell in the digital elevation map (DEM) was multiplied by –0.0134. In the Wiscland grid, all "red pine" cells were multiplied by –0.5292, all "grassland" cells by 0.2522 and all "mixed/other coniferous" cells by –0.532. The grids resulting from each calculation were added to the intercept (-24.214) to determine the logit ($\beta_0 + \beta_1 x_1 + \beta_2 x_2$ ...), from which the probability of *Ribes* occurrence was determined as in equation [1].

As expected from the model, the resultant map of *Ribes* occurrence (figure3, pg 44), shows a strong correlation with habitat type group as well as ecological region. The most consistent region of high Ribes occurrence (>90%) is on the dry mesic to mesic sections of the Western Coulee region in southwest Wisconsin and the lowest incidence occurs on the very dry to dry types within the Central Sand Plains, the Northwest Sands, the Northern Highlands, and the Northeast Sands.

Mathematical Modeling: Polynomial Regression

Predicting *Ribes* presence or absence could be done with logistic regression because the dependent variable is dichotomous, i.e. taking one of two values (present/absent). However, a mathematical model which a continuous dependent variable such as incidence or risk must depend on some sort of polynomial regression. The risk model we wanted to develop would predict the incidence of white pine blister rust in Wisconsin. A model of blister rust risk was published by Eugene Van Arsdel in 1968 (figure 4) and was based mainly on elevation and proximity to the Great Lakes. Areas below 1000 ft of elevation comprised zone 1 (very low risk), areas between 1,000 and 1,200 ft and along the shore of Lake Michigan made up zone 2 (low to moderate risk), areas below 1,400 ft in northern Wisconsin and above 1,200 ft in southern Wisconsin comprised zone 3 (moderate to high risk), and zone 4 (high risk) consisted of all areas above 1,400 ft , which only occur in northern Wisconsin.

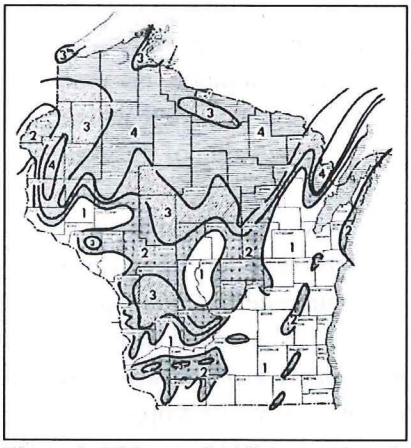


Figure 4. Risk map for blister rust based on elevation and proximity to large bodies of water (Van Arsdel 1968).

A study done in 2000 of blister rust levels across the state, however, showed a lack of correlation between observed incidence of rust and Van Arsdel's zones. We therefore, were interested in deriving a model using mapable factors which were correlated with blister rust incidence with the object of clarifying the risk zone issue. The model was based on data from 2 years of sampling (1998 and 2000) in seedling to sawtimber white pine stands throughout the state (Figure 5, pg 44). Although in both studies, local site factors such as high topographic position and aspect were significant, because they would be very difficult to map, they weren't included as independent variables in the model. The variables entered into the model were very similar to those used in the logistic *Ribes* model, i.e. ecological region, subsection, latitude, longitude, elevation, habitat type group, and Wiscland land cover type. Because of the low number of sampling points, subsections with fewer than 5 plots were excluded due to possible bias. In order to reflect the local topography, we entered a variable which measured variance in elevation within a 1000m buffer zone around each plot, i.e. plots located in hillier terrain, such as the Coulee region

Table 1. Independent variables in the final logistic model predicting the probability of *Ribes* occurrencelisted in order of descending importance in the model (F-statistic).

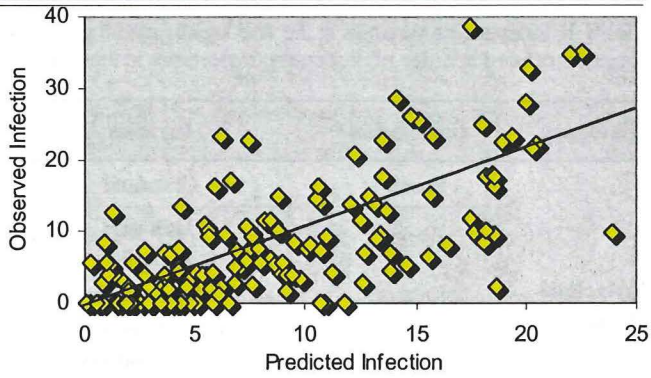
Category	Correlation	Variable	Chi-square	P-value
Wiscland Land Cover	Positive	Grassland	2.31	0.128
	Negative	Jack pine	2.70	0.100
		Red pine	3.72	0.054
		Mixed conifer	4.06	0.024
		Mixed decidous/coniferous	1.31	0.252
		Wet meadows	2.53	0.112
		Forested wetland: deciduous	2.35	0.125
		Forested wetland: coniferous	2.96	0.086
Habitat Type Group	Positive	Dry mesic to mesic	5.08	0.024
		Mesic	9.34	0.002
		Superior Clay	9.26	0.002
	Negative	Dry	144.26	<0.0001
		Dry to dry mesic	50.92	<0.0001
		Dry mesic	21.62	<0.0001
		Very dry to dry	18.27	<0.0001
		Mesic to wet mesic	8.40	0.004
Ecological Region	Positive	Western Coulee	78.60	<0.0001
	Negative	Northern Highlands	34.78	<0.0001
		Northwest Sands	20.10	<0.0001
		Central Sand Plains	19.05	<0.0001
		Central Sand Hills	11.07	<0.001
		Northeast Sands	13.68	<0.001
Habitat type within Ecoregion	Positive	Mesic in Northeast Hills	21.58	<0.0001
		Wet in Northeast Hills	15.88	<0.0001
		Wet in Northwest Sands	8.88	0.003
		Mesic in N. Lake Michigan Coastal	7.89	0.005
		Wet mesic in Farm-Forest Transition	5.34	0.021
		Dry mesic in Central Sand Hills	2.01	0.156
	Negative	Wet in Northeast Plains	11.03	<0.001
Subsection	Positive	222Lc	12.92	<0.0001
		222Ka	8.81	0.003
		222Md	3.73	0.053
		222Ld	2.41	0.121
		212Hb	2.24	0.134
		212Jg	2.02	0.155
		212Jd	1.62	0.203
		212Jk	1.47	0.226
		212Jm	1.23	0.268
	Negative	212Js	1.79	0.151
		212Je	1.64	0.200
Other	Negative	Longitude/latitude (northwesterliness)	54.44	<0.0001
		Elevation	15.66	<0.0001

of southwest Wisconsin, would have a higher local variance. In both the 1998 and 2000 studies, blister rust incidence was elevated on higher topographic positions. However, on a regional basis, mean incidence of blister rust was not correlated with elevation, in fact generally decreased with increasing elevation. This may be due to the fact that the highest elevations in the state are located mainly in the subsection, 212Jm or the Northern Highlands Pitted Outwash, which is characterized by dry sandy soils and a very low incidence of blister rust.

The variables in the final model are listed in Table 2 (next page). The R^2 for the final model was 0.72 with the intercept set to 0 (F=15.82, MSE=44.8, df=169). In this model, all categories of variables were of similar importance. The square of local elevation variance was quite significant, indicating the role of local topography in infection. Figure 6 (next page) illustrates the relationship between observed incidence and incidence predicted by the model (Pearson correlation =70.3%). Notice that the model underpredicts infection for plots with very high levels of rust (>20%). This illustrates the fact that site factors, such as proximity to *Ribes* or locally cool, humid conditions, may play a substantial role in determining the level of infection.

The map of predicted rust levels (Figure 7) again reflects the influence of habitat type, but not as strongly as with the *Ribes* coverage map. Plot locations are superimposed to illustrate the problem with extrapolating beyond

the range of the data. Several counties and ecological regions have no plots or very few. In this case, significant relationships with data that has statewide coverage, such as Wiscland land cover, elevation, habitat type, latitude and longitude can be very helpful. Survey work should emphasize, if possible, a uniform distribution of plots throughout the area of interest.



Summary

In this project, we have seen the advantages as well as the limitations of extrapolating data to a continuous coverage. In the interpolation technique, the strongest advantage is that the value of the generated surface at each data point is very close to the observed value. The only data that contributes at that point is the weighted average of its value and the 12 nearest neighbors. With modeling, there will necessarily be greater extrapolation and a less accurate approximation at that point. The advantage of modeling is the ability to incorporate other sources of data to more accurately represent the space between data points which hasn't, by definition, been surveyed.. These data sources often represent continuous surfaces which very accurately represent properties of the grid cells between data points, i.e. digital elevation maps and Wiscland land cover. This data is weighed through the regression procedure as to its significance in contributing to the value of the factor being modeled.

Table 2. Independent variables in the final regression model predicting the incidence of white pine blister rust, listed by category and in order of descending importance in the model (F-statistic).

Category	Correlation	Variable	F	P-value
Wiscland	Positive	Aspen	2.86	0.093
	Negative	Agriculture*	1.35	0.250
		Red pine	1.23	0.269
Habitat type group	Positive	Mesic to Wet mesic	6.52	0.012
	Negative	Dry mesic	5.27	0.023
		Dry to dry mesic	2.87	0.093
		Dry	2.18	0.142
Ecological Region	Positive	Western Coulee	4.56	0.035
	Negative	Northern Highlands	9.08	0.003
		Northwest Sands	4.27	0.041
Habitat type within Ecoregion	Positive	Mesic in Farm-Forest Transition	2.74	0.100
Subsection	Positive	222Md	22.99	<0.0001
		212Jd	7.18	0.008
	Negative	212Jj	6.22	0.014
		212Jl	4.88	0.029
		222La	3.29	0.063
		222Ld	2.17	0.143
Other	Positive	Elevation variance**	9.03	0.003
		Longitude + latitude (northeasterliness)	5.18	0.024
	Negative	ln Elevation	1.87	0.177
		ln Ribes***	1.48	0.225

* Includes row crops, forage crops, field crops and corn.
** Variance of elevation within 1000m of processing cell based on 30m grid DEM.
***Derived from the surface generated by logistic regression in this analysis.

With any source of data, however, it's important that an adequate number of evenly distributed plots be established. For this reason, the techniques illustrated in this study are merely an illustration of what can be done and certainly require improvement. The FIA plots are an invaluable source of evenly distributed plots throughout the state, but their value in documenting forest health problems may be limited. Detailed survey work is invaluable but also limited by the amount of work and expense required to establish a large number of evenly distributed plots.

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Assisted and Natural Spread of Parasitoids and Diseases in Newly Established Populations of Gypsy Moth: The Wisconsin Experience.

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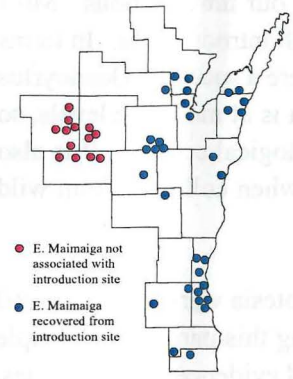
Gypsy moth was isolated from the nearest long established population in Michigan for years following establishment in Wisconsin. Given this isolation, we were concerned that natural spread of specialist enemies of this foreign pest might be slowed. We decided to conduct an initial survey of natural enemies of gypsy moth and implement a biological control introduction program.



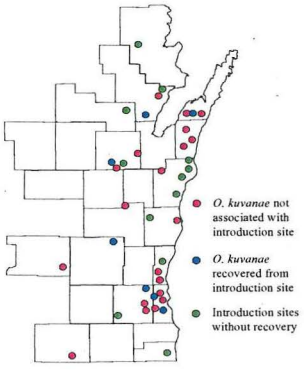
Survey of *E. maimaiga* done in 1996 - 2000

In the summers of 1996 and 1997 workers from the Department of Natural Resources placed burlap bands around preferred host trees at sites with relatively higher catches of male moths. Sites were checked twice weekly starting the first week of June through the third week of July. This corresponded to the period of third instar larvae through pupation. Larvae found under the bands were sent to a rearing facility where the cause of death of any that died prematurely was determined. When gypsy moth egg masses were found during population monitoring, we checked them for the presence of parasitoids.

We found Entomophaga maimaiga at one site in the Door Peninsula. Nucleopolyhedrosis virus (NPV) and Cotesia melanoscela were present at a site near the southern end of Green Bay. Dipteran parasitiods were present throughout the range of gypsy moth and some of these were identified as Compsilura concinnata. Ooencyrtus kuvanae was present at 5 sites in the base of the Door Peninsula.

Cadaver of a gypsy moth larva producing abundant *E. maimaiga* conidia, some of which remained attached to larval hairs.

Following the survey of parasitoids and diseases already present, we started an introduction program to supplement natural spread. We used three criteria in selecting candidate species; a high degree of specificity to the gypsy moth, the ability to establish in low-density gypsy moth populations and to survive in our climate, and availability. Using these criteria, we selected E. maimaiga, O. kuvanae and C. melanoscela for release. Introductions were made throughout the area where gypsy moth was established in Wisconsin for four years.


O. kuvanae not associated with introduction site
O. kuvanae recovered from introduction site
Introduction sites without recovery

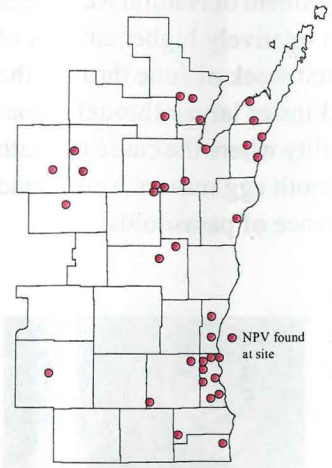
Survey of *O. kuvanae* done in 1996 - 2000

We introduced E. maimaiga using ground cadavers. Releases were done in September, October and November. By using, we expected to provide a more consistent distribution of spores and a higher concentration. We also avoided the possibility of introducing soil-borne pathogens. We introduced O. kuvanae as adults collected off of infested gypsy moth egg masses supplied from wild populations in Michigan. Release of the early fall generation of this species was emphasized to maximize the proportion of females. Captive bred C. melanoscela were released in late fall as overwintering cocoons as previous studies had shown this reduced mortality from parasitism. Despite this, emergence was an average of only 62%.

Post release surveys were done using the same procedure as before. Sites were

surveyed each year following an introduction through the summer of 2000. E. maimaiga was recovered at approximately 50% of its sites. Recovery appeared to be influenced by rainfall, natural spread also occurred into central Wisconsin in 2000. O. kuvanae was recovered at about 35% of the sites where we released it. Unassisted spread of this species has been rapid, however. We have not yet recovered C. melanoscela from either sites where it was released or at other sites.

The spread of E. maimaiga appears to have been assisted by our introductions. Natural spread, however will play a larger role during wet years now that gypsy moth is more generally established in the eastern areas of the state. This species is a good choice for introductions into newly established and isolated populations of gypsy moth. The risk of effects on non-targets is small, it can persist for many years, and while it can be difficult to make collections, it is relatively cheap. We would recommend to pest managers that the establishment rate might be improved by distributing spores soon after collection in mid-summer to avoid desiccation. Variation in the likelihood of recovery emphasizes the need to conduct post-release surveys for several years.



Survey of NPV done in 1996 - 2000

The spread of Ooencyrtus was not greatly aided by our introductions. Most populations found during surveys were not associated with introductions. In terms of public relations though, introductions of this species were a success. Ooencyrtus is an easy species for the public to find when gypsy moth is at moderate levels, so makes a good ambassador species for the concept of biological control. It is also easy to obtain, cheap, and fairly specific to gypsy moth when collected from wild populations.

We can't say how successful our introductions of Cotesia were due to limited efficacy of the burlap band survey technique at recovering this parasitoid. Simple searches of young larvae at release sites also failed to find evidence of this species, however. Pest managers might consider the ability to recover a species when selecting them as a lack of results could be a problem in maintaining support for a biological control program.

In order to improve biological control introduction programs, pest managers need more information on which natural enemies benefit from deliberate introductions, particularly when a species is expensive or difficult to obtain. More information of how to optimize conditions for establishment of each species would also be helpful.